THE IMPACT OF INCREASED PALLET UTILIZATION ON INTRA-THEATER AIRLIFT

GRADUATE RESEARCH PAPER

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AFIT/IMO/ENS/11-16

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Wright-Patterson Air Force Base, Ohio

AFIT/IMO/ENS/11-16

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GRADUATE RESEARCH PROJECT

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master Science in Logistics

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June 2011

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

AFIT/IMO/ENS/11-16

Abstract

U.S. Transportation Command (USTRANSCOM), the Distribution Process Owner (DPO) for the Department of Defense (DoD) supply chain, is responsible for moving all cargo from the United States to the combat zone. They have implemented a new initiative known as the Next Generation Cargo Capability (NGCC) whose goal is to obtain better pallet utilization for cargo traveling along this supply chain by increasing either the size or weight of the pallet. As pallets travel along the supply chain, they may be transported via multiple airframes and each airframe has a different cargo capability. The intra-theater airframes that are utilized for the final leg of the supply chain have the lowest cargo capability. This research attempts to determine the impact of building larger pallets on the intra-theater portion of the airlift system.

Pallets transported between Dover AFB, DE and the Afghanistan Area of Operations (AOR) were analyzed to determine how they compared to the NGCC utilization goals. The movement of pallets within the theater was analyzed to determine the impact the NGCC goals have on the intra-theater airlift system.

The results show that increased pallet utilization increases the amount of cargo moved to theater; however, if the pallets are not tailored for the intra-theater airlifters, the number of missions required to move pallets within the AOR increases. A recommendation was made to tailor more pallets to the requirements of the intra-theater aircraft to enjoy the benefits of increased pallet utilization without increasing the number of missions required.

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To my family.

Acknowledgements

Thanks to my family, friends and cats for all the support while I was working on this project. You provided timely comic relief that allowed me to be able to look at things from a different point of view. Many thanks to the members of the U.S. Air Force Expeditionary Center MOS/MOLT for all their help in teaching a pilot about load planning and building pallets. I would like to express my appreciation to my advisor, Dr. James T. Moore, who provided excellent guidance and feedback throughout the year.

Sandra J. Wilson

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Glossary

AB – Air Base
ACL - Allowable Cabin Load
AFB - Air Force Base
AMC – Air Mobility Command
AMCI – Air Mobility Command Instruction
AMCPAM – Air Mobility Command Pamphlet
AOR - Area of Responsibility (deployed theater)
APC – Aerial Port Code
APOD – Aerial Port of Debarkation
APOE - Aerial Port of Embarkation
B-747 - Boeing 747 aircraft
CCDR – Combatant Commander
CCP – Consolidation and Containerization Point
CONUS – Continental United States
CRAF - Civil Reserve Air Fleet
Cross-docking – Moving cargo from one mode of transportation to another without storing it
Cube – The volume of a pallet in cubic feet
DD – Department of Defense
DLA - Defense Logistics Agency
DMES – Deployable Mobility Execution System
DoD – Department of Defense
DPO – Distribution Process Owner
DTR – Defense Transportation Regulation
DTS – Defense Transportation System
EPP – Estimated Pallet Positions
FIFO – First In, First Out
GATES - Global Air Transportation Execution System
GTN - Global Transportation Network
GCC – Geographic Combatant Command
HT - Height
ID - Identification
Inter-theater - Cargo movement between theaters
Intra-theater - Cargo movement inside the deployed theater or AOR
JDDE – Joint Deployment and Distribution Enterprise
JDDOC – Joint Deployment Distribution Operations Center
JFC – Joint Forces Commander
LG- Length
MDS – Model Design Series (Type of Aircraft)
MHE - Material Handling Equipment
NGCC – Next Generation Cargo Capability
NMCS – Not Mission Capable Supply
OEF - Operation Enduring Freedom

Glossary

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NGCC – Next Generation Cargo Capability
NMCS – Not Mission Capable Supply
OEF - Operation Enduring Freedom
OIF – Operation Iraqi Freedom

OIF – Operation Iraqi Freedom
Para - Paragraph
POD - Point of Debarkation
POE - Point of Embarkation
POP – Proof of Principle
PSI – Pounds per square inch
RDD - Required Delivery Date
ROE – Rules of Engagement
RO/RO – Roll On/ Roll Off
s/t -short tons
SDDC - Surface Deployment and Distribution Command
SET – System Entry Time
SPM – Single Port Management
TACC – Tanker Airlift Control Center
TDD – Time Definite Delivery
TP – Transportation Priority
USTRANSCOM – United States Transportation Command
UTE - Utilization
VOL - Volume
WD - Width

THE IMPACT OF PALLET UTILIZATION GOALS ON INTRA-THEATER AIRLIFT

I. Introduction

Background

In 2003, U.S Transportation Command (USTRANSCOM) was named the Department of Defense (DoD) distribution process owner (DPO). As such, their mandate is to "improve the overall efficiency and interoperability of DoD distribution related activities" (TCJ5/4-S, 25 Aug 10). To help fulfill this mandate USTRANSCOM has implemented a new initiative known as the Next Generation Cargo Capability (NGCC) whose goal is to drive improvements in pallet utilization (Lovell, 2009). Better utilization of pallets would result in more efficient use of aircraft which would generate cost savings and could possibly result in a reduction of the number of aircraft required to fulfill supply chain requirements.

One of the process changes identified by NGCC is to implement weight and volume standards for pallet utilizations. These standards are specific to each aircraft and are based on the aircraft's cargo weight and size limitations. The NGCC rules of engagement call for pallets to be built to 90% of the maximum weight or 80% of the maximum volume by pallet position ("Dover", 2010). As pallets travel along the supply chain, they may be transported via multiple airframes that have different cargo capabilities. Pallets built to meet the NGCC standards on one aircraft may exceed the

next aircraft's capability. The intra-theater airframes that are utilized for the final leg of the supply chain have the lowest cargo capability.

Air cargo in the DoD supply chain flows along a multiple hub and spoke system. The pallet of cargo is built at a Defense Logistics Agency (DLA) warehouse or the aerial port of embarkation (APOE) and headed for the aerial port of debarkation (APOD), the final airfield before it is delivered to the customer. Pallets may be transferred between aircraft at each hub as they travel along the supply chain. The pallets can be built as pure pallets, where all cargo on the pallet is headed for the same destination, or mixed pallets, where cargo on the pallet is headed to multiple destinations. Some hubs have the capability to break down and rebuild pallets if required. Pure pallets should not have to be broken down and require less handling at the hubs. Intra-theater hubs have limited sorting capabilities compared to those outside the theater. Figure 1 depicts a generic view of the hub and spoke system.

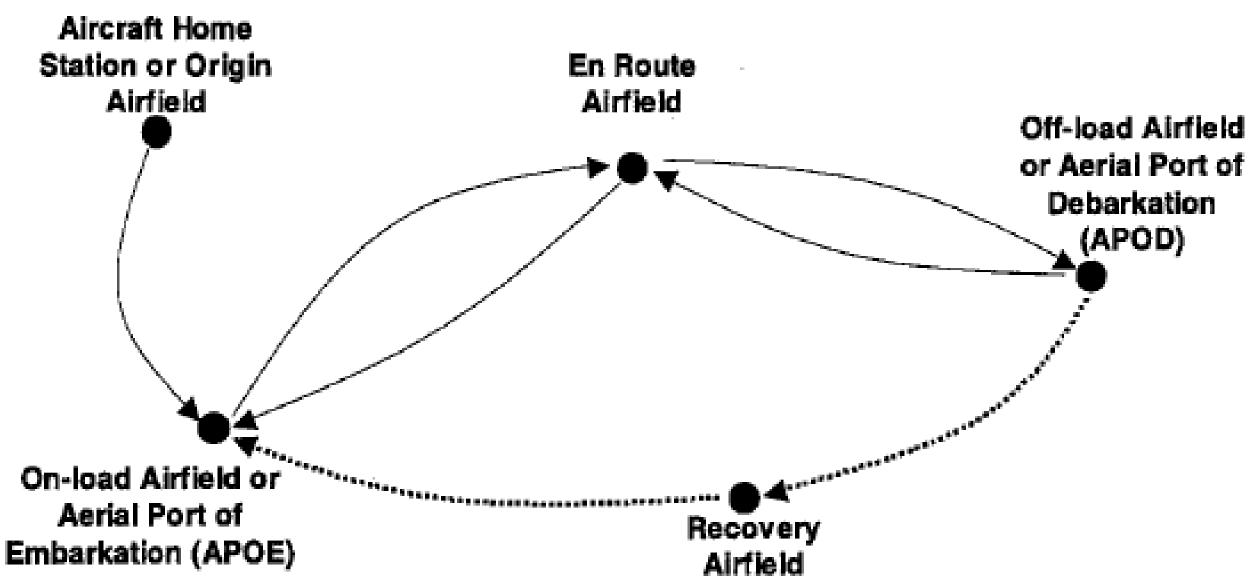


Figure 1. Hub and Spoke System (Brigantic and Merrill, 2004:650)

Problem Statement

As the DPO, USTRANSOM is charged with supplying the troops in the most effective and efficient method possible. The goal of the NGCC pallet utilization initiative is to improve efficiency of the supply chain by increasing pallet utilization and thus aircraft utilization while still remaining effective in getting the warfighter what they need when they need it. The purpose of this research is to determine if the implementation of the NGCC standards for pallet utilization have an effect on the intra-theater airlift system.

Research Focus & Investigative Questions

The goal of this research is to determine if the implementation of standards mandating all pallets departing the APOE be built to a specific weight or volume requirement affects the intra-theater portion of the DoD supply chain. This research will focus on the air mobility supply chain that moves cargo to the Afghanistan Theater of Operations in support of Operation Enduring Freedom (OEF). The researcher will utilize historical data from the Global Air Transportation and Execution System (GATES) to answer the following questions:

1. How do the NGCC weight/volume goals differ from current pallet building procedures?
2. Does increasing pallet weight/volume at the APOE affect intra-theater aerial port operations?
3. Does increasing weight/volume requirements increase the time it takes for supplies to be delivered to troops in theater?

The first question will be used to develop an understanding of how the new pallet utilization standards impact the overall system. The following two questions focus on the impact on the intra-theater portion of the supply chain.

Research Significance

The results of this research should enable personnel at USTRANSCOM and AMC to determine if the desired NGCC utilization rates are feasible in the current supply chain. The findings could result in a need to increase aerial port capabilities in theater or at another hub along the route or they may help determine cost savings due to a reduction in the number of aircraft required to move the heavier pallets. The data can also be used to determine if the current NGCC Rules of Engagement (ROE) generate increased delivery times thus requiring our customers to hold larger inventories in theater.

Scope

AMC moves over 2300 tons of cargo daily to points all over the globe (USTRANSCOM, 2011:19). The NGCC utilization goals will be implemented AMC wide and impact all cargo pallets transported for the DoD. In order to limit the scope of this project, this research will focus on the supply chain moving cargo from Dover AFB, DE to the airfields in Afghanistan. All types of cargo are moved throughout the DoD supply chain; however, because the NGCC goals focus on palletized cargo, this research is focusing only on single pallets of cargo that are moved from APOE to APOD via the defense transportation system.

The remainder of this paper addresses a review of literature to provide a background understanding for this research, the methodology applied to look at this issue, the results of the analyzed data, suggestions for future research, and conclusions.

II. Literature Review

Introduction

The objective of this literature review is to build the groundwork from which this research effort will be conducted. This chapter is divided into four main parts. The first part examines literature related to the Joint Deployment and Distribution Enterprise (JDDE) with a focus on inter- and intra-theater airlift portions of the DoD supply chain. The second part will discuss cargo handling operations with a look at cargo processing, palletization of cargo, aircraft load planning procedures and literature concerning load planning optimization. The third part will discuss the pure pallet program, why it was created and relevant literature which discusses its effectiveness. The final portion will discuss the Next Generation Cargo Capability (NGCC) program and how it ties all of these topics together. The researcher has determined that an understanding of these topics is vital in analyzing how pallet utilization goals are created and what they may impact.

Joint Deployment and Distribution Enterprise

The Joint Deployment and Distribution Enterprise (JDDE) provides joint force commanders (JFCs) the ability to rapidly and effectively move and sustain forces across the range of military operations. The JDDE community is made up of a collaborative network of DoD and partner organizations who share common distribution-related goals, interests, missions, and business processes, which comprise end-to-end distribution in support of combatant commanders (CCDRs). The JDDE acts based on requirements and

priorities established by the supported Geographic Component Command (GCC) and other supported organizations. As the Distribution Process Owner (DPO), USTRANSCOM is the single coordination and synchronization element that oversees all DoD distribution activities (JP 4-09, 2010: x). Strategic and theater deployment and distribution operations within the Area of Responsibility (AOR) are coordinated by the Joint Deployment Distribution Operations Center (JDDOC) (JP 4-09, 2010: xi).

The DoD supply chain is a global network that encompasses all DoD and commercial supply, maintenance, and distribution activities (JP 4-09, 2010: xi). The global distribution pipeline involves the intra-continental, inter-theater, and intra-theater movement of personnel and cargo (JP 4-09, 2010: xvii). Figure 2 shows a depiction of the global distribution pipeline. Coordination of the inter-theater and intra-theater movement is the shared responsibility of USTRANSCOM and the supported combatant command.

The Defense Transportation System (DTS) is the portion of the global distribution infrastructure that supports the DoD's common-user transportation needs. The Defense Logistics Agency (DLA) is the primary operator of the defense supply and depot system. They are responsible for acquisition, receipt, storage, and issuance of all materiel flowing in the defense distribution pipeline. USTRANSCOM assumes responsibility for the movement of the materiel as it enters the DTS. At the intra-theater level the GCC is responsible for distribution (JP 4-09, 2010: IV-4).

Air Mobility Command (AMC) is responsible for all CONUS based common-user air mobility assets. AMC aircraft may be temporarily attached to a GCC to provide intra-theater airlift capability (JP 4-09, 2010: II-7). AMC also performs single port

management (SPM) functions to support the flow of deploying forces, equipment, and supplies at the aerial port of embarkation (APOE) and passes control to the GCC at the aerial port of debarkation (APOD). AMC is responsible for port management through all phases of theater aerial port operations (JP 4-09, 2010: V-13). In its SPM role, AMC utilizes cross-docking to the maximum extent possible to expedite materiel through the distribution pipeline (JP 4-09, 2010: II-15).

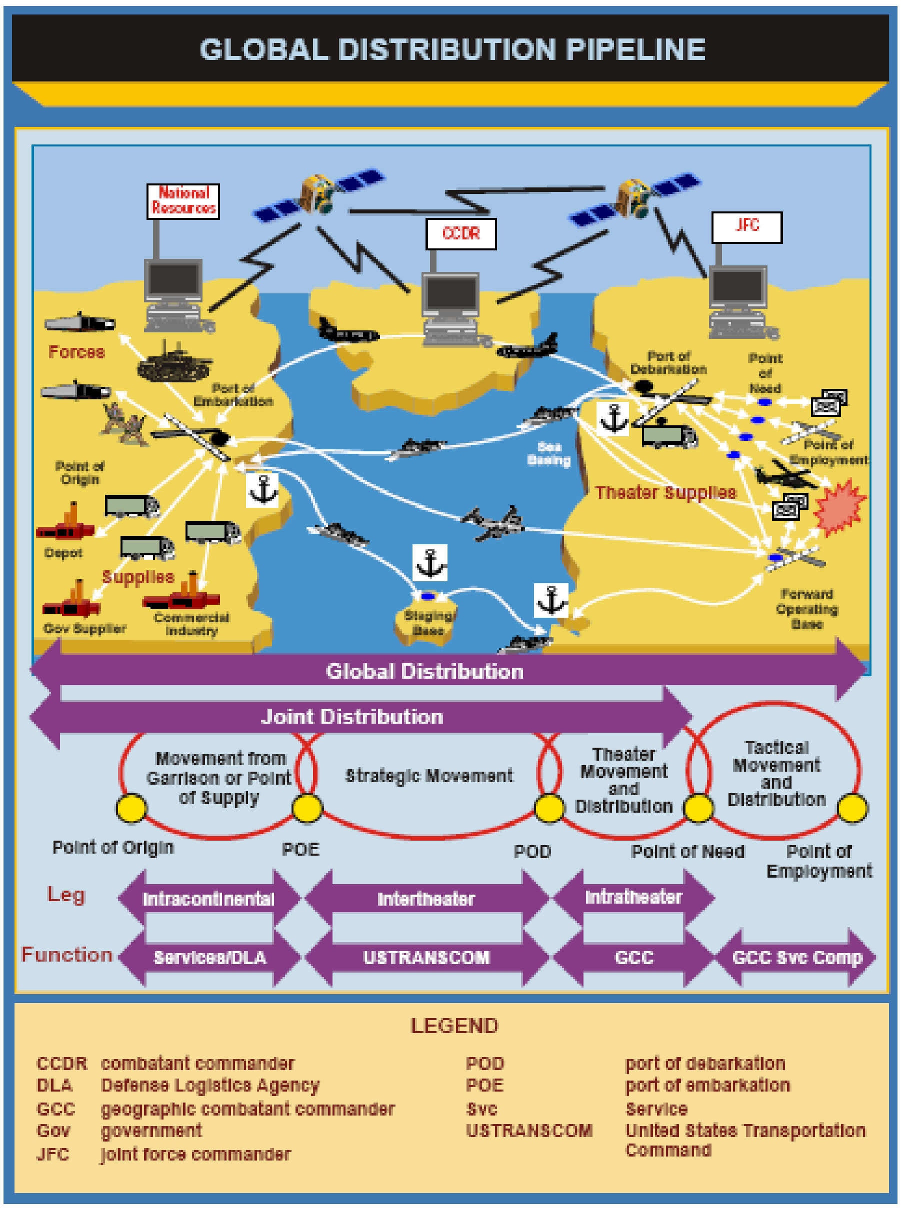


Figure 2. Global Transportation Pipeline (JP 4-09, 2010: I-2)

Physical network constraints restrict the flow of material through the DoD supply chain. These restrictions can create bottlenecks or conditions that limit or degrade the ability of the distribution to support an operation. Historically, limited numbers of ports and airfields, unloading capacity at ports and airfields, and limited inland transportation have constrained logistics support of combat forces (JP 4-09, 2010: III-5). As the DPO, it is USTRANSCOM's responsibility to anticipate congestion and seek solutions to these constraints.

Metrics are used to track trends, productivity, resources and other key performance indicators that may signal a problem with the distribution system. Six performance measures are used to describe the critical characteristics of the distribution system: velocity, precision, reliability, visibility, responsiveness, and efficiency. These metrics provide leaders with a balanced perspective of tradeoffs between efficiency and effectiveness enabling them to evaluate the potential cost of improved performance (JP 4-09, 2010: V-20).

The DoD airlift system is keyed for rapid response using both military and contacted commercial aircraft. Common-user organic military aircraft and certain commercial aircraft are configured to rapidly load equipment using roll-on/roll-off (RO/RO) ramps and the standard 463L pallet system (JP 4-09, 2010: II-24). However, there is a limited number of aircraft in the airlift system; therefore, the load for each aircraft must be optimized to ensure air assets are being used efficiently.

Cargo Handling Operations

The following information on cargo processing, palletizing cargo, and aircraft load planning was gathered from the Air Mobility Command (AMC) Advanced Distributed Learning System (ADLS) Computer Based Training (CBT) modules entitled Air Freight and Load Planning.

Cargo Processing

Originating cargo usually arrives at the aerial port of embarkation (APOE) via ground delivery. The APOE personnel will acknowledge receipt of the cargo, inspect the cargo and documentation, and accept the cargo into DTS by in-processing it into the Global Air Transportation and Execution System (GATES).

The cargo transportation priority (TP) is determined by the shipper based on guidance from DOD 4140.1-R, Appendix 8. The TP-1 is assigned to Time Definite Delivery (TDD) Category 1 requisitions with priority designators 01 through 03 and all RDDs, including a blank RDD field, except when the RDD starts with an "X" or an "S". A RDD starting with an "X" or "S" indicates that the materiel is required a number of months in the future. TP-2 is assigned to TDD Category 2 requisitions with RDDs 444, 555, 777, N__, or E__ or a RDD Julian date that is eight days or less from the Julian date the requisition or associated shipments are being processed for CONUS customers, 21 days for OCONUS customers. TP-3 is assigned to TDD Category 3 requisitions with priority designators and RDDs indicating routine handling (DTR Part II, 2009: II-203-2). All TP-1 cargo with expedite handling indicators must be processed within 12 hours of receipt. All other cargo for shipment via AMC contract carrier or military air transportation must be processed within 18 hours of receipt time (AMC, 2006: 21).

Most cargo coming into an enroute air terminal arrives by either AMC or commercial air conveyance. Some of the cargo may terminate at that station. In-transit and thru-load cargo will continue through the airlift system to another station. AMCI 24-101 Vol. 11 Para 31.2.3.1 states that all transit cargo and mail over 1000 lbs must be re-weighed to verify the weight documented on the original DD Form 2775. However, Para 24.1.6 says the local policy may require only a designated percentage of pallets to be re-weighed based upon the stations past performance. This must all be done in a timely manner to allow the cargo to be shipped to its final destination as quickly as possible.

Palletizing Cargo

The AMC airlift system moves vast amounts of cargo daily. Placing cargo on pallets helps expedite the loading and unloading of cargo aircraft. The 463L air cargo pallet is the basic pallet used within the DTS for pallet buildup. The 463L pallet is made of aluminum with a balsa wood core. It is designed to work with material handling equipment (MHE) and the cargo rail systems within AMC aircraft to properly restrain the cargo. An empty pallet weighs approx 290 lbs. The 463L pallet measures 108 x 88 inches and can hold up to 10,000 lbs of cargo. The usable area on the pallet is 104 x 84 inches to allow for the rail system inside the aircraft. The pallet surface weight limitation is 250 pounds per square inch (psi).

The selection of cargo and mail for palletization is based on the destination, priority and system entry time (SET) of the cargo. AMC guidance is that cargo and mail pallets will be built for one destination to the greatest extent possible. A goal of AMC is to utilize the aircraft space for maximum efficiency. Consequently pallets should be built

to enhance maximum aircraft utilization, subject to aircraft and weight limitations and cargo loading characteristics.

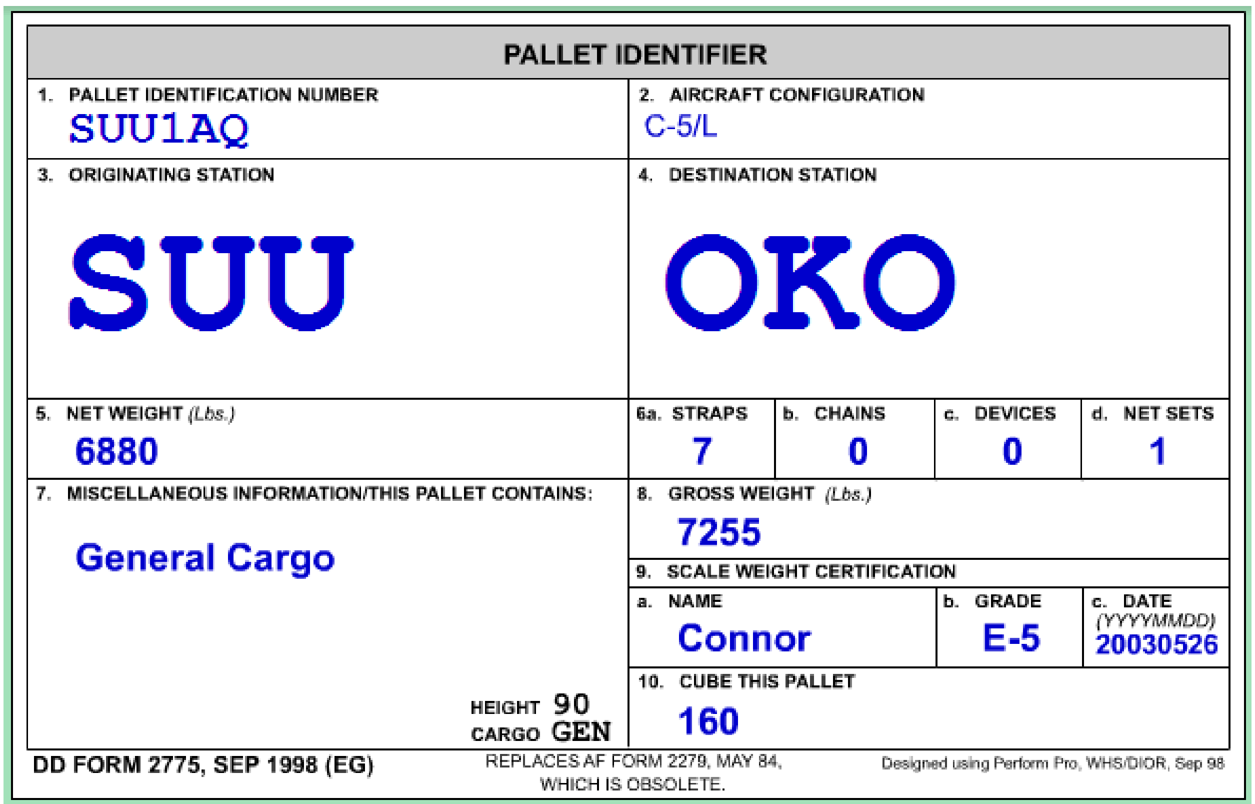
The cargo's configuration during pallet build up is important. Dense cargo and crated/boxed cargo should be loaded on the pallet first. Heavy items need to be evenly distributed from the center of the pallet outward to help maintain the center of balance at or near the center of the pallet. Crushable and light density cargo should be stacked on top of the load, or used as filler cargo around the high-density or crated /boxed cargo. The cargo should be stacked in a manner that allows the load to be tied together to prevent shifting on the pallet (i.e. a square or pyramid). The maximum height, measured from the surface of the pallet, of any pallet should not exceed a maximum of 96 inches if the pallet is 10,000 lbs or greater. A pallet can exceed 96 inches if less than 10,000 lbs and meets the airframe limitations. Sometimes the cargo that is being palletized may not fit in the usable area of the pallet. This is referred to as overhang. If the cargo does not exceed 120 inches and the overhang can support itself, it can be put on a single pallet and the overhang annotated in the estimated pallet position (EPP) entry for GATES. If the cargo is greater than120 inches it must be built on a multi-pallet train.

Cargo should be secured to the pallet with tie downs appropriate for the palletized cargo's weight and the height. A net is typically used for cargo that fits within the pallet size constraints. The nets are designed to connect with the pallets' D-rings. Top and side nets may be used in a variety of combinations depending on how the cargo is configured on the pallet.

Once a pallet is configured and secured, it must be weighed to obtain the gross weight. The pallet must also be properly labeled with a DD Form 2775, Pallet

Identification. The pallet must be labeled on two sides using the DD form 2775. The placards should be placed in clear, plastic-zippered bags. The duplicate, signed copy of the pallet contents listing should also be placed in one of these bags on the pallet, behind the DD Form 2775. These "packets" should be attached directly on the pallet, on the upper left-hand corner, at eye level on the 88 and 108 inch sides of the pallet. Figure 3 shows an example of the DD Form 2775.

Once the pallet is build with documentation attached, it is stored to await shipment. Where the pallet is stored may depend on the pallet contents. Most pallets of general cargo will be stored in a grid. Pallets with perishable cargo may need to be stored out of the elements. Pallets containing special cargo may have a separate location.



PALLET IDENTIFIER

1. PALLET IDENTIFICATION NUMBER	2. AIRCRAFT CONFIGURATION
SUU1AQ	C-5/L
3. ORIGINATING STATION	4. DESTINATION STATION
SUU	OKO

5. NET WEIGHT *(Lbs.)*	6a. STRAPS	b. CHAINS	c. DEVICES	d. NET SETS
6880	7	0	0	1

7. MISCELLANEOUS INFORMATION/THIS PALLET CONTAINS:	8. GROSS WEIGHT *(Lbs.)*		
General Cargo	7255		
	9. SCALE WEIGHT CERTIFICATION		
	a. NAME	b. GRADE	c. DATE *(YYYYMMDD)*
	Connor	E-5	20030526
HEIGHT 90 CARGO GEN	10. CUBE THIS PALLET 160		

DD FORM 2775, SEP 1998 (EG) REPLACES AF FORM 2279, MAY 84, WHICH IS OBSOLETE. Designed using Perform Pro, WHS/DIOR, Sep 98

Figure 3. DD Form 2775, Pallet Identification.

Palletization is an enormous asset to the transportation system. It has reduced loading and off-loading time greatly. It also allows aircraft loads to be prepared long before an aircraft arrives.

Aircraft Load Planning

The purpose of load planning is to ensure each aircraft is loaded to best utilize the aircraft's capabilities while maintaining safety. The load plan specifies the type of cargo to be loaded, and the cargo's sequence. It also ensures the aircraft is within its weight and balance limits. AMCI 24-101 Vol. 9 lists the duties and responsibilities of a load planner.

The load planner is responsible for inventorying cargo, selecting and inspecting cargo, sequencing cargo, creating the load plan, and preparing all cargo/mail manifests. Cargo selection is based on mission destination, cargo priority, and system entry time (SET). The inherent priority of some cargo requires it to be assigned higher movement priority over other cargo. However, mission requirements or proper movement authority decisions may override the cargo priority assigned by the load planner. The load planner's main job is to ensure maximum utilization of each aircraft based on available airlift and existing port backlogs.

Each aircraft can be configured in various ways to transport troops, palletized cargo, rolling stock or a combination. The aircraft configuration determines the numbers of seats and pallet positions available. It also determines whether rollers are up or the floor is smooth. All of these considerations will affect the amount and type of cargo moved on that particular aircraft.

Load planners must think about the space they are filling with cargo. Sometimes cargo must be contoured in a certain way to fit in the cargo compartment. When a pallet must be built with an aisle way for passenger considerations or with a specific contour to fit airframe limitations, the pallet shape is denoted by a module type. Module types are codes describing the cargo characteristics. Some module types fit certain aircraft or certain pallet positions. Appendix A contains a listing of pallet module types.

Physical space is not the only factor determining how cargo can be loaded onto an aircraft. The weight of the cargo and how it is placed on the aircraft also determines the total amount of cargo the aircraft can carry. The Allowable Cabin Load (ACL) is the maximum allowable payload that can be carried on an individual sorties. If the ACL is exceeded, the aircraft may not be able to take off, or its internal structure may be damaged due to the excess loading.

There are several types of ACL that load planners must consider. These include peacetime planning ACL, wartime planning ACL, takeoff ACL, landing ACL, and zero fuel ACL. Zero fuel is the maximum amount of cargo weight the aircraft should carry, not including the weight of fuel or oil. Peacetime planning ACL provides a guideline for the maximum cargo weight carried by the aircraft on a daily basis. Wartime planning ACL usually represents a significant increase over the peacetime planning ACL. Takeoff ACL is the max amount of cargo weight the aircraft can carry to safely take off. Landing ACL is the max amount of cargo weight the aircraft can carry to safely land at its intended destination. Defense Transportation Regulation (DTR) Part III Appendix V lists the peacetime and wartime planning ACL's for DoD aircraft. Takeoff, landing, and zero fuel weight ACL's are computed on the DD Form 365-4 by the load planner and aircraft

loadmaster. ACLs for commercial aircraft are based on the contract ACL agreed upon between AMC and the CRAF participant and can be found in the AMCPAM 24-2 series. Table 1 shows the ACL's for various transport aircraft used in the DoD airlift system.

Table 1. Allowable Cabin Loads for various commercial and military airlifters.

	Peacetime Planning ACL	Wartime Planning ACL	Max ACL	Contract ACL
C-5	150,000 lbs	175,000 lbs		
C-17	90,000 lbs	107,900 lbs		
C-130	25,000 lbs	38,800 lbs		
B747-200			240,000 lbs	180,000 lbs
B747-400			259,400 lbs	180,000 lbs
MD-11			192,000 lbs	

Load planning has garnered attention by both commercial and military air transportation experts with the hopes of increasing aircraft utilization and overall efficiency of the air transportation industry. The Deployable Mobility Execution System (DMES), a computer load planning program to improve aircraft utilization and responsiveness in airlift operations was developed in 1985 by Cochard and Yost (53). The introduction of DMES saved hundreds of man-hours that had been required by the previous manual load planning process as well as reducing the number of missions required by at least 10 percent (Cochard, 1985: 68). Jarvis et al. [1988] developed a linear program with the objective of minimizing the number of planes required to move a specific load (Rappoport, 1991:66). Rappoport et al. [1991] looked at maximizing the weight, volume, and square footage that could be moved by a given fleet (66). Ng [1992] used an integer goal programming formulation to grapple with load planning cargo by priority on a C-130 (1204). Chan et al. [2006] developed a two-phase intelligent decision support system to address the loading of air cargo on to pallets and loading of the pallets

onto the aircraft to ensure maximum utilization (472). Yan et al. [2006] developed a cargo container loading plan model for international express carriers to minimize the handling costs incurred as the cargo travelled through their network (445). The variety of angles taken by researchers' in addressing load planning, points to the efficiencies that can be garnered from good load planning throughout the air transportation network.

Pure Pallet Program

Since being named the DPO in 2003, USTRANSCOM has employed various initiatives to improve the distribution system. One of these is the pure pallet program. The pure pallet program was developed by AMC in 2004 in response to long and highly variable distribution times that had plagued the supply chain for Operation Iraqi Freedom (OIF) (Dye, 2006: 22). A pure pallet was defined as a pallet that contains cargo destined for a single customer. Prior to this, pallets were built with cargo destined for the same aerial port of debarkation (APOD) which ensured higher pallet and aircraft utilization to make the most efficient use of airlift assets (Dye, 2006: 26). This practice required the APOD to break down the pallet and sort the cargo before it could be distributed to the final customer, which they were undermanned for (Diamond, 2008:53). This resulted in shipment delays and pilferage as cargo sat at the port until someone could process it. In contrast, a pure pallet could be trans-loaded from one aircraft to another and reach forward deployed locations in almost no time at all.

The pure pallet process starts at the APOE where cargo is separated into lanes by the DoD address code for their final destination. The process worked great for customers who required significant amounts of cargo to be delivered; however, it was very

inefficient for customers requesting supplies that did not fill an entire pallet. Since airlift is a limited resource, it is imperative to maximize the efficiency of each aircraft by utilizing full cargo loads. In order for enough cargo to accumulate to create a pure pallet the Army's maximum allowable cargo hold time was increased from 48 hours to 120 hours and the Marine Corps' cargo hold time was increased from 48 to 72 hours (Mongold, 2006: 20). Address codes of several smaller locations were combined to ensure there was enough cargo for a pallet. The pure pallet program was deemed a success! Initial results showed that pure pallets made it to theater in less than nine days while mixed pallets had been taking weeks (Diamond, 2004: 54).

Since the launch of the pure pallet program, several papers have been written addressing its effectiveness. In 2006 Mongold and Johnson concluded that the pure pallet might not be effective in all distribution systems because it increases the manpower required at the APOE; however, their overall results showed that the pure pallet program did improve system effectiveness (31). A 2006 AFIT thesis entitled *Perceptions of the Pure Pallet Program* found that the pure pallet program was effective in decreasing end-to-end distribution times and reducing the number of lost shipments (Dye, 2006:100). In 2007, Jackson looked at the viability of the pure pallet program for retrograde operations and found that program was not appropriate for retrograde operations which supports Mongold's conclusion that it would not be effective in all situations (Jackson, 2007: v). The success of the pure pallet program has lead to new initiatives to improve the efficiency and effectiveness of the global distribution network.

Next Generation Cargo Capability (NGCC)

The Next Generation Cargo Capability (NGCC) initiative was launched by USTRANSCOM in 2009 with the goal of transforming current business processes to maximize aircraft utilization and expedite asset delivery while integrating the modernized B-747-400 aircraft into CRAF for AMC channel and contingency missions. Since its inception, the goal has expanded to drive improvements in pallet utilization. Improved pallet utilization would result in improved aircraft utilization and efficiency for all AMC missions (Lovell, 2009).

As part of NGCC, USTRANSCOM identified five process changes that could potentially increase pallet utilization. These include modifying the contour pallet ROEs, standardize pallet utilization standards for weight and cube, develop dense cargo lanes at the consolidation and containerization points (CCP) and aerial ports, refine the pure pallet route plan, and review materiel flow to the aerial port (Lovell, 2009). AMC/A4T has been tasked to implement and evaluate these process changes.

In early 2010 AMC/A4T developed weight and cube standards in an effort to standardize pallet utilization standards. These standards can be found in Appendix B. A proof of principle (POP) test began at Dover AFB in October 2010. The ROEs for the POP covered both cargo processing and aircraft load planning. The ROE state that all pallets should be built to 90% of the established weight goal or 80% of the established cube goal for that pallet module type. Cargo would still be processed under the first-in/first-out (FIFO) authority; however, it was relaxed to allow for increased pallet utilization. Non-pure pallets could be held up to 48 hours unless the pallet goals could be achieved sooner. Pure pallets could be held up to 120 hours to meet the pallet goals.

Load planners were asked to ensure aircraft were loaded to meet 90% of their ACL or 80% of the volume weight. If an aircraft was less than 70% utilized by weight or cube TACC must be contacted for a go/no-go decision. Load planners were also given flexibility to FIFO to allow pallets to aggregate up to 120 hours for a specific mission to meet utilization goals ("Dover", 2010). The expected benefits of the new processes are an improvement in support to the warfighter by reducing bottlenecks within the AOR and potentially moving up to 25% more cargo with the same amount of airlift. Figure 4 shows a depiction of how the NGCC process would be implemented (Finney, 2010).

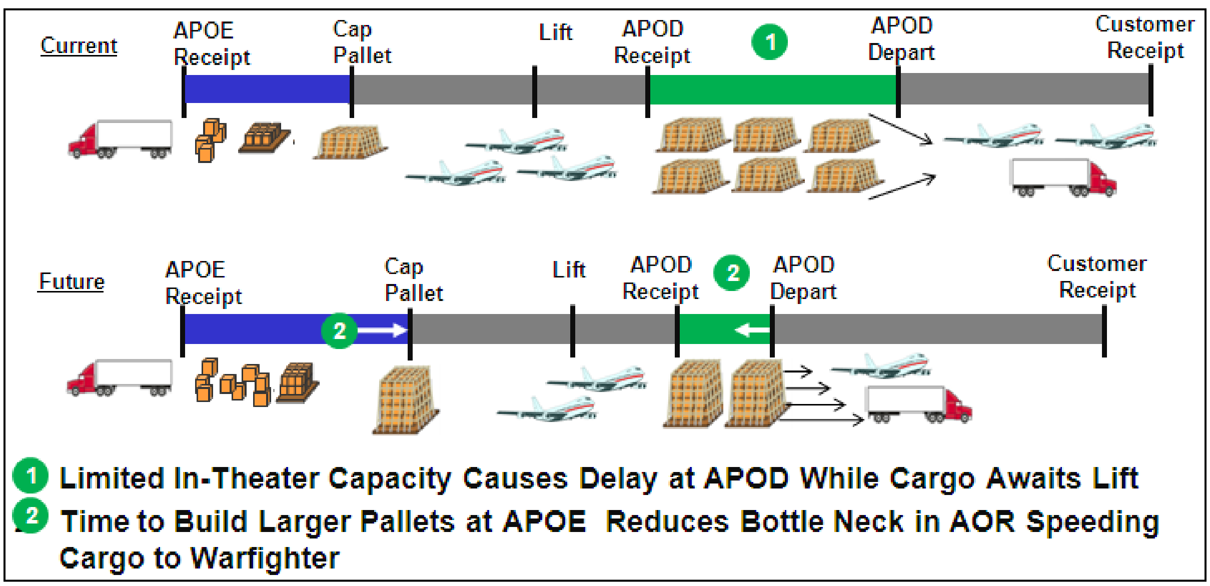


Figure 4. Visual depiction of how NGCC concept will speed cargo to warfighter

The goal of the proof of principle was not to validate the pallet utilization goals set by AMC/A4T but to work on balancing velocity and utilization through the pipeline. The initial weight goals will be implemented and the results will be recorded. These results will be used to rebalance the lift based on the volume of empty positions on

aircraft and establish new aircraft utilization goals and planning factors. The proof of principle is currently on-going and results have not been reported (Finney, 2010). The goal of this paper is to address how the process changes implemented for the NGCC initiative might impact the intra-theater portion of the defense transportation system.

Summary

This chapter built a foundation from which to conduct this research effort. The first part of the chapter addressed joint deployment and development enterprise with a focus on the inter- and intra-theater portions of the DoD supply chain. The next part delved into the cargo handling process to build knowledge about cargo processing, palletizing, and load planning procedures. The third portion looked at the pure pallet program and its effectiveness as a USTRANSCOM initiative to improve the DoD supply chain. The final portion introduced the Next Generation Cargo Capability initiative and its anticipated benefits. This research will look at possible impacts the NGCC initiative could have on the intra-theater portion of the DoD supply chain.

III. Methodology

Introduction

The goal of this chapter is to provide a detailed account of the methodology used in this research effort. This chapter begins with an explanation of the data from GATES that was used in this research. The next section will develop the air mobility distribution network from Dover AFB, DE to the Afghanistan AOR so the reader can visualize the system these pallets are moving in. The third section will review the research questions in order to provide a focus for the methodology discussed. The fourth section discusses the data analysis techniques used in this research to answer the research questions. The fifth section discusses the assumptions and limitations of the research. The chapter concludes with a summary of the methodology.

The Data

The researcher utilized historical Global Air Transportation and Execution System (GATES) data collected during June of 2011 that was provided by AMC/A9. The GATES database contains information for every pallet traveling along the aerial portion of the DoD supply chain. Each line in the database provides detailed information for an individual pallet which includes when and where the pallet was built, gross and net weight, and pallet volume which is more commonly referred to as cube. The database also includes the mission number and type of aircraft on which the pallet travelled. Figure 5 shows a screenshot of the data from GATES.

ATMS_ID	PAL_ID	PAL_DT	PLT_GROSS_WT	APC	APOE_MSN_ID	APOE_LEG_ID	MNFST_APOD	APOD_MSN_ID	APOD_LEG	DEP_DT_TM	MDS	TAIL_NUM
AU1100600006	1015MH	6/1/10 11:35	7270	DOV	PBR03Z70E154	100	OA1	PVR03Z80E156	550	6/3/10 4:10	C005B	60011
AU1100400870	1015MJ	6/1/10 11:56	3320	DOV	ABR02Y70B158	100	KDH	AVR02Y80B160	500	6/7/10 7:29	C005B	50003
TB5100671214	1015MJ	6/1/10 11:56	3320	OA1	FMJA5574A171	100	OA2	FMJA5574A171	200	6/20/10 13:30	C130H	30489
MSN_PRIOR	**ARR_DT_TM**	**APOE_APC**	**APOD_APC**	**PAL_APOE**	**PAL_APOD**	**PLT_VOL**	**PLT_HT**	**PLT_NET_WT**	**PLT_PCS_QY**	**PLT_TY_CD**	**PALLET_TYPE**	**EVQ_PAL_PS**
1B1	6/4/10 23:16	DOV	OA1	DOV	OA4	455	90	6825	1	B	PC	10
1B1	6/12/10 21:52	DOV	KDH	DOV	OA2	395	78	2965	1	L	PC	10
1B1	6/20/10 15:05	OA1	OA2	DOV	OA2	395	78	2965	1	L	PC	10

Figure 5. Screenshot of GATES data

The following will define the variables that were used to sort the data. The header showing where that variable is in the data is in parenthesis next to the variable name.

<u>Pallet Identification Number (PAL_ID)</u>: Every pallet is assigned a Pallet ID to aid in tracking the pallet. Pallet ID is an identifier used to control and manage a number of individual pieces of cargo, which have been brought together and aggregated into a single shipment unit. This field uses a six character format. The six character format includes the first three-digits of the Pallet ID which consists of an Aerial Port Code (APC) for the Aerial Port which built the pallet and the last three positions of the Pallet ID which are alphanumeric characters representing a unique identifier.

<u>Pallet Date/Time (PAL_DT)</u>: The unique date and time when the pallet was created at the originating port.

<u>Pallet Gross Weight (PLT_GROSS_WT)</u>: Contains the combined weight of a pallet or container and its contents, including packaging material.

<u>Current Aerial Port Code (APC):</u> The aerial port code for where the pallet currently is located.

<u>Model Design Series (MDS)</u>: Contains the formal classification for an aircraft type.

<u>Pallet APOE (PAL_APOE)</u>: The aerial port code which represents the embarkation point of the pallet.

<u>Pallet APOD (PAL_APOD)</u>: The aerial port code which represents the debarkation point of the pallet.

Pallet Volume (PLT_VOL): The volume of the pallet in cubic feet (ft^3). For mail pallets the volume is set to zero.

Pallet Height (PLT_HT): The height of the pallet in inches (in).

Pallet Type Code (PLT_TY_CD): Contains the module type code describes the specifics (i.e., type of pallet, where the pallet should be placed in a particular type of aircraft) of how cargo has been configured on a 463L pallet for loading of an aircraft. An explanation of these codes can be found in Appendix A.

Pallet Type (PALLET_TYPE): Contains the type of cargo that the Pallet ID is related to. Although it is labeled pallet type, this code shows if that cargo is on a single pallet, pallet train, skid, or rolling stock. The key for these codes can be found in Appendix C.

Equivalent Pallet Positions (EVQ_PLT_PS): Contains the number of pallet positions used by a pallet or pallet train. The equivalent pallet position is a two-digit numeric field with an assumed decimal point.

The original data file provided to the researcher contained all cargo that was moved via the air mobility supply chain between 1 June 2010 and 30 June 2010. The file contained a total of 24,970 entries. Table 2 shows the breakdown of the data by pallet type.

The NGCC utilization goals are for single pallets and therefore the researcher only considered palletized cargo with the PC type code. In order to scale down the amount of data being considered, the researcher focused only on cargo headed from Dover AFB, DE to the Afghanistan Theater of Operations. Of the 21,911 palletized cargo entries 8,048 entries were headed to Afghanistan and 5,277 of these entries originated at Dover.

Table 2. Breakdown of GATES data by type of cargo

Type of Cargo	**Number of Entries**	**Percentage of Total**
Palletized Cargo (PC)	21,911	87.75%
Rolling Stock (RS)	1,620	6.49%
Pallet Train (T*)	953	3.82%
Belly Cargo (BC)	347	1.39%
Skid (SD)	88	0.35%
Loose (LS)	50	0.20%

While looking through these 5,277 data entries, the researcher noted that there were several double entries. In order to eliminate these redundancies, the researcher used Microsoft Excel's sorting function to sort the data by Pallet ID. The researcher then used IF statements to figure out which lines were duplicates. Before deleting any duplicate lines, the researcher looked at the matching entries to determine if it was indeed a double entry. The researcher noted that some of the double entries were exactly the same while others were identical except for the Pallet Date/Time. For the entries that had differing Pallet Date/Time stamps, the researcher deleted the line with the earliest Pallet Date/Time stamp. There were also entries where the pallet appeared to depart and return to the same aerial port. It was assumed that these missions must have returned to base for some reason. If the pallet departed the same station at a later date, the returned entry was deleted. If there was not an entry showing that the pallet had departed the station, the returned entry was kept and it was assumed that the pallet was still at that aerial port. Using these sorting techniques the researcher eliminated 320 double entries leaving them with 4,957 entries for pallets that moved between Dover AFB, DE and Afghanistan.

The original data provided did not have all the information the researcher needed to complete the analysis so other information was obtained through the researcher's own

searches of the GATES database. The researcher ran a Super Track and Trace (TnT) query of the GATES database from 1 June 2010 to 31 June 2010 to determine if the pallets were pure or mixed pallets. Figure 6 shows the data acquired from the Super TnT query.

Plt_ID	APOE	APOD	Cubes	Pieces	Plts	Weight	Net_Tons	Mission_ID	TCN
1011AK	DOV	AZ3	395	1	1	1965	1	JBRGKZ70D119	SW31230115D035XXX
1011AU	DOV	AZ3	400	1	1	2005	1	JBRGKZ70D119	SW31230115D041XXX
1011EL	DOV	AZ3	435	1	1	3605	1.8	BBR1XZ70P121	SW31230117D297XXX

Out_Hgt	Out_Lbs	Out_Len	Out_Pcs	Out_Wdt	ULN	Mod_Type	Pallet_DateTime	Plt_Cnfg	Pure_Pallet
78	1980	104	1	84		G	03:43.0	PC	Pure_Pallet
79	1960	104	1	84		G	39:26.0	PC	Pure_Pallet
86	3605	104	1	84		L	33:14.0	PC	Pure_Pallet

Figure 6. Data from Super TnT query of GATES database.

The researcher matched the Pallet ID from the original data that was provided with Pallet ID's found in the Super TnT query. For all Pallet ID matches, the information in the Pure_Pallet column was transferred to the spreadsheet of data the researcher was working with. If a Pallet ID was not matched, a "0" was entered into the column. Using this technique, the researcher was able to gain pure pallet information for 96% of the data.

The researcher also ran a Historical Cargo On-Hand query of the GATES database to attain required delivery date (RDD) information for the pallets. The Historical Cargo On-Hand query returned all cargo that was at an aerial port between 1 June 2010 and 30 June 2010. Figure 7 shows the data returned from the Historical Cargo On-Hand query.

Plt_ID	APOE	APOD	Cubes	Pieces	Plts	PPos	Gross_Wgt	TCN
1011AK	DOV	AZ3	395	1	1	1	2320	SW31230115D035XXX
1011AU	DOV	AZ3	400	1	1	1	2360	SW31230115D041XXX
1011EL	DOV	AZ3	435	1	1	1	3990	SW31230117D297XXX
RDD	**PartPlts**	**Pallet_DateTime**	**Plt_Cnfg**	**Plt_Hgt**	**Pure_Pallet**	**RSS_Train**	**Type_Module**	**Event_DateTime**
999	1	03:43.0	PC	76	Pure_Pallet	Over/Out	G	50:00.0
999	1	39:26.0	PC	76	Pure_Pallet	Over/Out	G	50:00.0
999	1	33:14.0	PC	86	Pure_Pallet	Over/Out	L	27:11.7

Figure 7. Historical Cargo On-Hand query results.

The researcher matched the Pallet ID from the original data that was provided with Pallet ID's found in the Historical Cargo On-Hand query. For all Pallet ID matches, the information in the RDD column was transferred to the spreadsheet of data the researcher was working with. If a Pallet ID was not matched, a "0" was entered into the column. Using this technique, the researcher was able to gain RDD information for 88.26% of the data.

Air Mobility Network

In order to understand the flow of the pallets into the Afghanistan Theater of Operations, the data was sorted by the mission aerial port of embarkation (APOE) and mission aerial port of debarkation (APOD). This allowed the researcher to map the various routes the pallets could take to their final stop (PAL_APOD). There were several legs that were only travelled along once during the June 2010 time period of the data. These were considered to be a case-by-case basis and therefore not included in the overall diagram of the air mobility network. The number of pallets that travelled along each leg was summed to gain an understanding of the flow along that leg. The type of aircraft used on each leg was also summed to determine which aircraft and thus cargo capability was normally on that leg. The resulting hub and spoke network can be found in Figure 8.

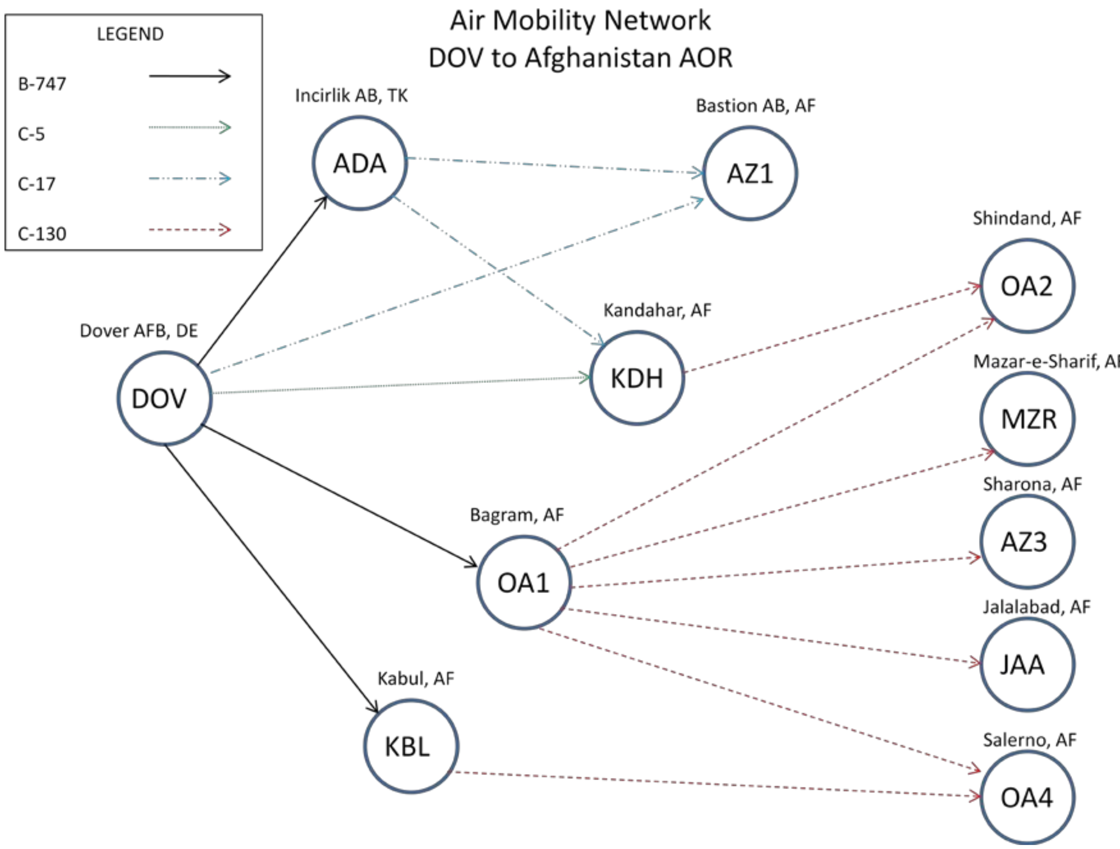


Figure 8. Air Mobility Distribution Network from DOV to Afghanistan AOR

Research Questions Review

In order to determine the impact of the NGCC utilization goals on the intra-theater airlift portion of the DoD supply chain, the researcher posed three investigative questions. The first question looks to compare historical pallet utilization to the current NGCC utilization goals. The second question looks at the effect of increasing pallet weight/volume on intra-theater aerial ports. The third question seeks to determine if increasing the weight/volume requirements would increase the time it takes for supplies to be delivered to troops in theater. These questions will be answered through the analysis of the GATES data using the techniques discussed in the following section.

Data Analysis Techniques

NGCC pallet utilization goals are set by aircraft and each aircraft has certain pallet types assigned to it. The NGCC utilization goals can be found in Appendix B. In order to determine how the pallets built from 1 June 2010 to 30 June 2010 compared to the NGCC utilization goals, the researcher broke the data down in two ways, by aircraft and by pallet type. Utilization rates were calculated for weight, height, and cube. The weight utilization rate was calculated as a percentage by dividing the gross weight (GROSS_WT) of the pallet by the NGCC suggested weight for 100% utilization.

$$Weight\,Ute = \frac{PLT\_GROSS\_WT}{Weight\,Goal} x100\%$$

Height utilization was calculated as a percentage by dividing the pallet height (PLT_HT) by the NGCC suggested height for 100% utilization.

$$Height\,Ute = \frac{PLT\_HT}{Max\,Height} x100\%$$

Cube utilization was calculated as a percentage by dividing the pallet volume (PLT_VOL) by the NGCC suggested cube for 100% utilization.

$$Cube\,Ute = \frac{PLT\_VOL}{Cube\,Goal} x100\%$$

Mail pallets are coded by setting the PLT_VOL to zero. The data set did not contain any mail pallets.

Utilization by Aircraft

Pallets are normally built to fit the aircraft they are going to fly on. To ensure the aircraft for the first leg was the one that the utilization data was compared to, the data was first sorted by departure date/time (DEP_DT_TM) and then by the pallet ID before the

duplicates were removed. Table 3 shows the breakdown of where pallets were when they first appeared in the data set. All of the pallets considered had a pallet APOE of Dover AFB, DE therefore; the researcher opted to not consider the 470 entries that did not originate at DOV. Table 4 shows the breakdown of pallets by the aircraft they first travelled on in the data set.

Table 3. Breakdown of pallets first location in the data set.

APC	Count	Percentage
ADA	466	12.78%
DOV	3177	87.11%
OA1	4	0.11%
Total	3647	100.00%

Table 4. Breakdown of aircraft that pallets leaving DOV departed on.

MDS	Count	Percentage
B74710	77	2.42%
B74720	1453	45.73%
B74740	348	10.95%
MD011F	675	21.25%
C005*	281	8.84%
C017A	343	10.80%
C130*	0	0.00%
Total	3177	100.00%

The data was sorted by the aircraft they flew on (MDS) and utilization was calculated by comparing the pallet type (PLT_TY_CD) to the NGCC goals by pallet type for that aircraft. The NGCC utilization goals only provided data for certain pallet types on certain aircraft. For example, the NGCC goals for the C-17A are only listed for pallet type L. Therefore all pallets, regardless of the pallet type, were compared to pallet type

L. For those aircraft with utilization goals for multiple pallet types the pallet types were compared to those available for the aircraft. The researcher used the LOOKUP function in Microsoft Excel to determine which pallet type each pallet should be compared against. If the actual pallet type is not available in the LOOKUP table, the pallet was compared to the pallet type that preceded it. For example, the Boeing 747 has NGCC utilization goals for B, E, and L pallet types. If a pallet type of F was carried on a Boeing 747, its utilization rates were calculated using the utilization goals for a type E pallet. A pallet of type M would be compared to the L pallet utilization goals. The utilization rates were then counted using the COUNTIF function to determine how many pallets met the NGCC requirement of 90% of the weight goal or 80% of the cube goal. Height utilization rates were counted to determine how many pallets exceeded the maximum height for that pallet type. An overall utilization rate was calculated by averaging the utilization rate per aircraft and multiplying it by the percentage of total pallets that aircraft carried.

Utilization by Pallet Type

The researcher observed that the NGCC goals for each aircraft did not account for all of the pallet types that were moved on that airframe and therefore, decided to compute utilization by pallet type as well. The data was sorted by pallet type and utilization was calculated by comparing that pallet type (PLT_TY_CD) to the NGCC goals. For pallet types that had two different utilization goals for the same pallet type, the lowest weight and cube goals were used to calculate the utilization rates for that pallet type. Table 5 shows the breakdown of each pallet type in the data set. The NGCC goals specify utilization rates for pallets of type B, D, E, F, H, J, L, N, P, Q, R, and X. However, the

data included pallets that are of types G, I, M, and T. These pallets made up a very small percentage of the data and therefore the researcher decided to not consider them when computing the utilization rates. The utilization rates were counted using the COUNTIF function to determine how many pallets met the NGCC requirement of 90% of the weight goal or 80% of the cube goal. Height utilization rates were counted to determine how many pallets exceeded the maximum height for that pallet type. An overall utilization rate was calculated by averaging the utilization rate per pallet type and multiplying it by the percentage of total pallets that the aircraft carried.

Table 5. Data broken down by pallet type

PLT_TY_CD	Count	Percent	PLT_TY_CD	Count	Percent
B	317	8.69%	M	55	1.51%
C	0	0.00%	N	113	3.10%
D	0	0.00%	P	5	0.14%
E	1015	27.83%	Q	17	0.47%
F	1	0.03%	R	16	0.44%
G	2	0.05%	T	6	0.16%
H	0	0.00%	V	0	0.00%
I	11	0.30%	W	0	0.00%
J	0	0.00%	X	0	0.00%
L	2089	57.28%			
			Total	3647	100.00%

Impact on Intra-Theater Aerial Ports

The majority of intra-theater movement in the Afghanistan Theater of Operation is accomplished by C-130 aircraft. The C-130 has the lowest cargo capacity of all the aircraft used in the air mobility supply chain. The C-130 has a total of six pallet positions. Three of these positions require the pallet to have either a 6 inch (positions 3 or 4) or 18 inch (position 6) aisle way on at least one side of the pallet. The majority of

pallets are not built with these aisles. Therefore, the intra-theater aerial port will have to rebuild the pallet to create an aisle way or the C-130 will be underutilized with only three of the six available pallet positions filled.

In order to determine how the intra-theater aerial ports would be affected by the NGCC utilization goals, the data set was sorted by the aerial port of debarkation (PAL_APOD). Cargo arrives in theater to one of four main aerial ports or hubs: Bagram (OA1), Bastion (AZ1), Kabul (KBL), and Kandahar (KDH). From these aerial ports the cargo is distributed via C-130 to the non-hub airfields. The data set contained 696 pallets that were destined for one of the non-hub APOD's. Table 6 shows the breakdown of pallets to each non-hub airfield. Although Jalalabad (JAA) and Mazar E Sharif (MZR) are not C-130 only airfields, the data showed that the majority of pallets going to those destinations were carried on C-130s.

Table 6. Breakdown of Pallets to Non-hub Airfields

Airfield Name	**PAL_APOD**	**Count**	**Percentage**	**C-130 Only?**
Sharona	AZ3	277	39.80%	Y
Jalalabad	JAA	120	17.24%	
Mazar E Sharif	MZR	129	18.53%	
Shindand	OA2	64	9.20%	Y
Salerno	OA4	92	13.22%	Y
Tereen	TE2	14	2.01%	Y
	Total	696	100.00%	

The C-130E/H mode is capable of carrying a total of 6 pallets: 3 type L, 2 type J, and 1 type H. A type J pallet has a 6 inch aisle way and can fit in the wheel well pallet positions. A type H pallet has an 20 inch aisle way and is sized to fit in the ramp pallet position. However, as Table 5 shows, there were no type H or J pallets in the data set. In

order to determine how many pallets could fit in the wheel well and ramp positions, the dimensions of all the pallets were calculated. The pallet height (PLT_HT) and volume (PLT_VOL) were provided for each pallet. In order to calculate the other dimensions of the pallet, the length (PLT_LG) was set to 84 inches for all pallets and the width (PLT_WD) was found by dividing the volume in cubic inches by the height and length. The equation used is shown below.

$$PLT\_WD = \frac{(PLT\_VOL \ x \ 12^3)}{(PLT\_HT \ x \ PLT\_LG)}$$

These dimensions were then used to determine if the pallet could fit in the ramp or wheel well positions. In order to fit in the ramp position the pallet must have a width (PLT_WD) of less or equal to 84 inches, a height (PLT_HT) less than or equal to 76 inches, a weight (PLT_GROSS_WT) less than 4664 pounds, and be only equivalent to one pallet positions (EVQ_PLT_PS). The wheel well position required the pallet be no wider than 98 inches, have a height of 96 inches or less, and be only equivalent to one pallet position. If a pallet did not meet the ramp or wheel well requirement it was assumed that it would fit in one of the remaining three pallet positions. The only exception to this was if the pallet had an equivalent pallet position greater than one. These pallets were considered to take up two pallet positions. The total count of pallets positions required were then input into a linear program that minimized the number of missions required to deliver those pallets.

The linear program has three inputs: number of ramp pallets, wheel well pallets, and remaining pallets. If the number of ramp pallets is greater than the number of wheel well pallets the program redistributes the pallets assuming that all ramp pallets can fit into the wheel well position. The program then determines the number of missions required

and how many pallets are on each aircraft to deliver all the pallets to the destination. The algorithm for the linear program can be found in Appendix D.

The results of the linear program assume that none of the pallets were rebuilt with appropriate C-130 aisle ways at the in-theater aerial port. A minimum number of missions required to deliver the pallets was also calculated by dividing the number of pallets by 6. The minimum number assumes that enough pallets could be rebuilt with aisle ways so that each C-130 was full. Although it is not feasible to expect that every C-130 mission would be completely full, it is not possible to determine which pallets could be rebuilt with an aisle way because the data set does not include the contents and arrangement of the items on the pallets.

To determine how the current NGCC goals would affect the intra-theater aerial ports the NGCC dimensions for the pallet types that were destined to non-hub airfields were compared to those that could fit on a C-130. Because the NGCC goals only call for 90% weight utilization or 80% cube utilization, these values were compared to determine the number of pallets that could fit in the ramp and wheel well positions. These numbers were then input to the linear program and the minimum number of missions to move them was calculated.

Intra-theater delays

The increased utilization goals of the NGCC program could cause either increased port hold time at the APOE while they wait for more cargo to the same destination or an increase in the number of mixed service and mixed APOD pallets to meet the utilization goals. This could result in a delay in the goods being delivered to the customer. The data provided showed the date and time that the pallet was capped (PAL_DT_TM). There

was not any data provided on port hold times so the researcher determined that an analysis of the transit time and ability to meet RDD would provide insight into how the NGCC goals might affect delivery time to the customer.

The researcher was able to find RDD's for 3,219 pallets in the data set. The RDDs can fall into one of many categories. If the RDD is left blank, the customer is okay with the published delivery time. If a Julian Date is entered into the RDD that date represents the day the customer wants to receive it. If the RDD has an entry of 444, 555, or 777 these codes show that the customer is requesting expedited shipment. If the RDD is set to 999 the item is considered critical and must be sent immediately. An RDD with an N followed by number between 00 and 99 represent a replacement for a part that is currently in non-mission capable status due to supply (NMCS) (DoD 4140.1-R, 2003: 244). A COUNTIF function was used to determine the percent of cargo that fell into each category. Because there is a possibility for cargo to be delayed waiting to meet NGCC goals, these values will be used to understand the percentage of pallets that can actually be delayed.

The data set provided had 2,742 pallets that were tracked from their initial departure out of Dover AFB all the way to their final destination. The time that the pallet was capped and the mission arrival time at the pallet's final destination were converted to Julian date and then subtracted from each other. The result was considered to be the transit time of the pallet. Six entries showed a negative transit time and were therefore disregarded for this study. The remaining 2,735 entries were sorted by their destination and an average and maximum transit time was calculated for each location. The data was

also sorted by required delivery date (RDD) to find the average and maximum transit time for each RDD category.

Assumptions and Limitations

Understanding the potential impact of the NGCC pallet utilization goals on the intra-theater portion of the Defense Transportation System required that several assumptions be made. Several of the assumptions were discussed in the sections above describing the methodology for analyzing the different aspects of the problem. In order to perform the analysis the researcher assumed that all the information that was collected from GATES was accurate. It was also assumed that the period of data analyzed was a representative sample of daily operations throughout the year.

The representation of the distribution network for Afghanistan was built off the path that the majority of pallets travelling to each destination took. The data set did not trace every pallet to its final destination; therefore, it is possible that other routes could have been taken to each destination. The data set showed that the majority of intra-theater movement occurred on C-130 aircraft. However, it is possible for other aircraft to land at some of the non-hub airfields in Afghanistan which would allow for more pallets to be moved to that location per mission. The assumption that all intra-theater movement of cargo was performed by C-130s provides the most limited scenario for cargo movement within the theater.

The analysis of the number of C-130 missions required was limited by the fact that the data set did not provide a description of the items on each pallet. This prevented the researcher from investigating if the pallet could be rebuilt to meet C-130 ramp or

wheel well pallet position requirements. The data only provided the height and volume of the pallet. It was assumed that the length of each pallet was the maximum dimension of 84 inches and the width was determined from these dimensions. This could have resulted in a miscalculation of the number of pallets that could fit in the ramp and wheel well pallet positions which would impact the number of C-130 missions required to distribute the pallets.

In order to be conservative, it was assumed that all movement in theater was performed by C-130E/H models which have six available pallet positions. In reality some movement is performed by C-130J models which have eight available pallet positions. Therefore, the number of missions required to move the pallets could be reduced if some of the missions used C-130J aircraft.

Summary

The goal of this chapter was to ensure the reader has a clear understanding of the rationale for the methodology discussed and enable the reader to retrace the researcher's path. In order to determine the impact of the NGCC utilization goals on the intra-theater portion of the supply network GATES data from June 2010 was analyzed and several different aspects of it were addressed. This analysis is not all-inclusive and has several assumptions and limitations. However, understanding how current utilization differs from the NGCC goals, analyzing the current number of C-130 missions required versus the number required if all pallets were built to NGCC standards, and understanding the delays that the larger pallets could see provide a good overview of areas in which the

utilization goals may impact the intra-theater portion of the distribution network. The results and analysis are included in Chapter IV.

IV. Results and Analysis

Introduction

This chapter begins with a comparison of the pallets built at Dover, AFB and headed for the Afghanistan Theater of Operations in June 2010 to the proposed NGCC pallet utilization goals. The total cargo actually moved in June 2010 is then calculated and compared to the cargo that could have been moved if the pallets had been built to NGCC standards. A dollar per ton rate will be calculated using USTRANSCOM's fiscal year 2011 rates for each aircraft type discussed.

The next part of the chapter will look at the number of C-130 missions required to move the cargo destined for the non-hub airports in Afghanistan. The non-hub airfields include Sharona (AZ3), Jalalabad (JAA), Mazar E Sharif (MZR), Shindand (OA2), Salerno (OA4), and Tereen (TE2). The number of C-130 missions required will be based upon the C-130E/H models ability to carry six pallets. The number of missions required for the pallets in June 2010 will be compared to the number of missions required if those pallets were built to NGCC standards.

The third part of the chapter will discuss the transit time and RDD distribution of pallets headed to the Afghanistan Theater of Operations. The breakdown of transit time and RDDs for the pallets that were delivered in June 2010 will be analyzed. The impacts of how NGCC goals may impact these times will be addressed as well.

The fourth section of this chapter will discuss possible adjustments to the NGCC goals to decrease the impact on the intra-theater portion of the airlift system. The overall

benefits that could be attained by the researcher's proposed goals will be compared to the current utilization and the NGCC utilization goals.

The chapter concludes with a summary of the results and analysis and how the data provided can be used by AMC and USTRANSCOM.

Pallet Utilization Analysis

Pallet utilization was calculated both by aircraft and by pallet type code.

Utilization by Aircraft

The pallet utilization by aircraft analysis considered only the aircraft that the pallet departed DOV on. If the pallet did not have a leg leaving DOV, the data for that pallet was not analyzed. Table 4 in section III shows the breakdown of aircraft that departed DOV. The NGCC goals state that a pallet should be built to 90% of its weight goal or 80% of the cube goal before that pallet is capped and ready to move. The number of pallets meeting these standards was found by counting the number of pallets that met the 90% weight goal and the number that met the 80% cube goal and then subtracting the number of pallets that met both the 90% weight and 80% cube. Table 7 shows the percentage of pallets that met NGCC utilization goals by aircraft. The percentage of pallets meeting utilization goals as they left DOV was then calculated by multiplying the percentage of pallets moved by an aircraft by the percentage of pallets that met utilization goals for this aircraft. The overall percentage of pallets leaving DOV that met NGCC utilization goals was found to be 59.87%. This value can be found in the last column of Table 7.

Table 7. Percentage of pallets meeting NGCC goals by aircraft

	Total Pallets Moved	Percent meeting NGCC goals	Overall percent meeting goals
B747-200	1530	62.81%	30.25%
B747-400	348	69.83%	7.65%
C-5	281	70.82%	6.26%
C-17A	343	64.43%	6.96%
MD-11F	675	41.19%	8.75%
Total	3177		59.87%

This value shows that the implementation of NGCC pallet utilization goals will definitely increase the amount of cargo that is moved on each aircraft. The values above were based on the utilization rates set for each aircraft. An analysis of utilization based on the pallet type code is presented in the next section.

Utilization by Pallet Type

The analysis of utilization by pallet type only included those pallets with types that had NGCC utilization goals set for them. If the pallet type did not have utilization goals set, it was not analyzed. Some of the pallet types had two different values for utilization goals depending on the aircraft type. The lowest weight and cube goals for that pallet type were used to calculate the utilization rates for those pallets. The number of pallets meeting NGCC weight or cube utilization standards were then calculated as described in the section above. Table 8 shows the percentage of pallets meeting the NGCC utilization goals by type and the overall percentage of pallets that met utilization goals. The overall percentage of pallets built at Dover that met the NGCC utilization goals for their pallet type was found to be 70.22%.

Table 8. Pallet utilization by pallet type code

Pallet Type Code	Total Pallets Moved	Percent meeting NGCC goals	Overall percent meeting goals
B	317	61.20%	5.43%
E	1015	66.21%	18.81%
F	1	100.00%	0.03%
L	2089	77.41%	45.26%
N	113	12.39%	0.39%
P	5	20.00%	0.03%
Q	17	35.29%	0.17%
R	16	25.00%	0.11%
Total	3573		70.22%

The results show that a greater percentage of pallets are meeting the NGCC goal for utilization by pallet type than by aircraft. This is expected because several aircraft had different goals for the same pallet type and this analysis only accounted for the utilization goal that had the lowest standards. This difference also shows that pallets are more likely to meet utilization goals by type rather than by aircraft. Therefore, further analysis of the possible savings by implementing the NGCC utilization standards will be conducted using standards by pallet type code and not by aircraft.

Comparison of Total Cargo Moved

The total cargo weight and cube were calculated for the June 2010 data to determine how these totals would change if the pallets were built to the NGCC goals. The total weight for each pallet type was found from the data provided and an average weight was calculated. The NGCC weight goal for each pallet type was multiplied by the number of that type of pallets moved to determine the total weight that could have been

moved. The total for 90% of the NGCC weight goal was also calculated. The analysis showed that if all pallets were built to 90% of NGCC weight goal, 5.39% more cargo could have been moved. If all pallets were built to 100% of the NGCC weight goal, 17.10% more cargo could be moved with the same number of missions. These results are shown in Table 9.

Table 9. Comparison of NGCC weight goals to actual data

PLT_TY_CD	**Count**	**Average Weight (lbs)**	**NGCC Goal (lbs)**	**90% NGCC (lbs)**	**Actual (lbs)**
B	317	3,628	3,880	3,492	1,149,960
E	1,015	2,584	3,062	2,756	2,623,091
F	1	6,870	4,527	4,074	6,870
H	0	0	3,133	2,820	0
J	0	0	4,618	4,156	0
L	2,089	4,142	4,800	4,320	8,652,209
N	113	2,899	4,729	4,256	327,550
P	5	2,592	3,810	3,429	12,960
Q	17	2,716	4,143	3,729	46,180
R	16	1,625	3,000	2,700	26,000
Total moved	3,573	12,844,820	15,041,475	13,537,524	12,844,820
Difference		0	2,196,655	692,704	
Percent		0.00%	17.10%	5.39%	

The same calculations were performed looking at the cube utilization rates. These results showed that at 80% of the NGCC cube goals, 12.57% more cargo volume could be carried. If the pallets were built to 100% of the NGCC cube goals, 40.78% more cargo volume could be carried on the same missions. The results of the cube analysis are shown in Table 10.

The NGCC cube goals maximize the size of each pallet to fit the dimensions of the cargo compartment. The NGCC weight goals were calculated by dividing the total number of pallet positions available by the aircraft's planned allowable cargo load. The

results of this analysis therefore tell us that the majority of pallets will weight out before cubing out.

Table 10. Comparison of NGCC Cube Goals to Actual Data

PLT_TY_CD	Count	Average Cube (ft^3)	NGCC Goal (ft^3)	80% NGCC (ft^3)	Total (ft^3)
B	317	270	384	307	85,485
E	1,015	168	303	242	170,703
F	1	231	448	358	231
H	0	0	310	248	0
J	0	0	457	366	0
L	2,089	371	475	380	775,145
N	113	198	468	374	22,345
P	5	84	377	302	421
Q	17	161	410	328	2,745
R	16	103	420	336	1,644
Total	3,573	1,058,719	1,490,455	1,191,851	1,058,719
Difference		0	431,736	133,132	
Percent		0.00%	40.78%	12.57%	

Cost Savings of Pallet Utilization

The main goal of the NGCC is to better utilize aircraft and therefore the researcher decided to perform an analysis of cost savings that could be realized by this initiative. The rate for CRAF carriers is given in dollars per ton-mile while the rate for DoD aircraft is given as cost per flying hour. The researcher used the planning ACL and published cruise airspeed to translate the rates for DoD aircraft into cost per ton-mile. Table 11 shows a rate, in dollars per ton-mile, for each aircraft. The rates for the C-5 and C-130 are based on the C-5A and C-130H models because they had the highest cost per flying hour (“A15-1”, 2010).

Table 11. Rate per ton-mile for AMC aircraft

B-747	MD-11	C-5A	C-17	C-130H
$ 0.41	$ 0.41	$ 1.04	$ 0.58	$ 1.86

Contract rates for commercial carriers are provided as a cost per ton-mile ("Proposed", 2010). Therefore, increasing the tons provided does increase the amount paid for the commercial aircraft. However, the rate for commercial aircraft is much lower than for the DoD aircraft. Because the rate for DoD aircraft is based on cost per flying hour, the increased pallet utilization will provide for more cost-efficient use of these aircraft.

Impact on Intra-Theater Aerial Ports

In order to determine how the intra-theater aerial ports would be affected by the NGCC utilization goals, the data set was reduced to 696 pallets that were destined for one of the non-hub APOD's. The pallets were broken down by the pallet APOD and the number of C-130 missions required was calculated using the linear program described in Appendix D. Table 12 shows the inputs for and results of the linear program for all of the non-hub airports. The equivalent number of pallets to be moved was determined by counting the number of pallets that had an EVQ_PLT_PS greater than 10. The number of H pallets includes the number of pallets that met the requirements to fit in the C-130 ramp position. The number of J pallets includes the number of pallets that met the requirements to fit in the C-130 wheel well positions. The number of L pallets includes the number of remaining pallets that do not fit in the ramp or wheel well positions.

Table 12. Linear Program Results for C-130 Missions Required

	AZ3	JAA	MZR	OA2	OA4	TE2	Total
Total Pallets	277	120	129	64	92	14	696
Equivalent Pallets	288	125	133	64	97	15	722
H Pallets	20	17	10	8	26	3	84
J Pallets	29	14	10	2	14	1	70
L Pallets	239	94	113	54	57	11	568
Legs Required	80	32	38	18	19	4	191

In order to determine how the NGCC utilization goals would affect this movement, all pallets were considered to be built to 100% of the utilization goal for their pallet type code. The original data did not include any H or J type pallets and therefore there are only three C-130 pallet positions that could be used on each mission. A type R pallet would be able to fit in the C-130 wheel well positions. However, there are not any R pallets that were headed for a non-hub airport. Table 13 shows the number of missions required if all pallets were built to NGCC standards.

Table 13. C-130 Missions Required if NGCC goals are met.

Legs Req'd	**AZ3**	**JAA**	**MZR**	**OA2**	**OA4**	**TE2**	**Total**
6 pallets per plane	47	20	22	11	16	3	119
Actual June data	80	32	38	18	19	4	191
Implement NGCC goals	96	42	45	22	33	5	243

The minimum number of legs required was calculated by assuming that each C-130 was fully loaded with six pallets. If every C-130 flew full, 119 missions would be required to deliver all the pallets headed to non-hub airfields each month. The number of legs required if the NGCC goals are met was calculated by dividing the equivalent

number of pallets that needed to be moved by three since only three pallet positions on the C-130 could be used. If all pallets were built to the NGCC standard for that pallet type, 243 missions would be required.

Another option would be for the aerial port to build an aisle way onto the pallets to meet the C-130 ramp and wheel well requirements. Assuming that the pallets could be rebuilt, the number of pallets that would need to be rebuilt, in order to move all pallets in the same number of missions as required by the linear program results, was calculated using the following formula.

$$Pallets\ \ to\ \ rebuild\ = Equivalent\ \ Pallets - (LP\, results\ \ x\ 3)$$

This equation calculates the number of pallets that do not have to be rebuilt by multiplying the number of missions required by the linear program by the number of pallet positions that do not have aisle way requirements and subtracting that from the total number of equivalent pallets. In order to move the pallets in the same amount of missions required currently, the intra-theater aerial ports would be required to build an aisle way into 149 pallets each month. Currently the hub airfields in theater are not manned to be able to rebuild the pallets and therefore more personnel would be required to perform these operations (Peterson, 2011).

Intra-theater Delays

In order to determine if pallets could afford to be delayed at the APOE for more cargo to accumulate, the percentages of pallets by RDD were calculated. The results can be found in Table 14.

This analysis shows that 66.88% of the pallets have an "expedite" or "critical cargo" RDD. Another 26.25% of the pallets have a Julian Date entered for the RDD which means that the standard delivery time will not get it there in time. This means that the majority of cargo cannot afford to wait longer at the APOE for more cargo to accumulate. This means that cargo to another location may be added to the pallet to meet the NGCC utilization goal which would increase the number of mixed pallets travelling through the system. An increased number of mixed pallets could result in longer delays at enroute aerial ports for the pallet to be broken down and rebuilt.

Table 14. Breakdown of Pallet RDD's

RDD	Count	Percentage
999	2031	63.09%
777	110	3.42%
555	9	0.28%
444	0	0.00%
N*	3	0.09%
0	221	6.87%
JD	845	26.25%
Total	3219	100.00%

The data provided did not show how long the cargo had sit at the APOE before it was put on a pallet and capped; therefore, it is not possible to determine how long it took cargo with a critical or expedited cargo RDD to reach the APOD. The 714 pallets with a Julian date for an RDD were analyzed to determine how well they met their RDD. A histogram of the data is shown in Figure 9.

If the time between the RDD and actual arrival date is negative the pallet arrived after the RDD. If the time is positive, the pallet arrived before the RDD. The average delivery time was -9, meaning 9 days after the RDD. The standard deviation of the data

was 33 days. The majority of pallets are already arriving after their RDD and therefore further delays caused by waiting for more cargo to the same destination or having to break down a mixed pallet at an enroute stop would result in the pallet missing the RDD by even longer.

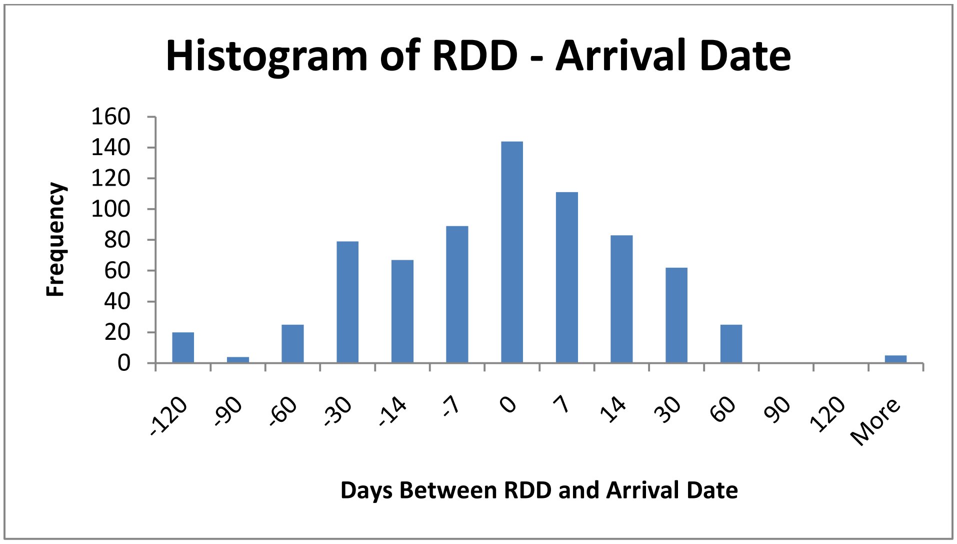


Figure 9. Histogram of Days between RDD and Actual Arrival Date

The NGCC Rules of Engagement say that mixed pallets may be held up to 48 hours and pure pallets may be held up to 120 hours to meet the utilization goals ("Dover", 2010). In order to determine how these delays would affect the time for cargo to make it to theater, the transit time for each pallet that made it to its APOD. The transit time was calculated by subtracting the Julian date for when the pallet was capped (PAL_DT) from the Julian date for when the pallet arrived at the APOD (ARR_DT_TM). An average transit time for each pallet to make it to the APOD was calculated for each of the airfields in Afghanistan. Table 15 shows the average transit time, minimum transit time, and maximum transit time for each APOD in Afghanistan that had pallets make it to their final APOD in June 2010. The transit time from Dover AFB (DOV) to Tereen

(TE2) could not be calculated because the data set did not contain any pallets that made it to their final APOD of Tereen. The maximum transit time for a pallet was 36 days for three pallets headed to Kabul (KBL). The minimum transit time was one day for several pallets that were headed to Bagram (OA1).

Table 15. Transit times for pallets from DOV to each APOD in Afghanistan

APC	Entries	Avg (days)	Min (days)	Max (days)
AZ1	888	5	2	27
AZ3	104	7	3	26
JAA	3	6	5	8
KBL	97	9	2	36
KDH	697	5	2	16
MZR	41	7	3	14
OA1	870	4	1	21
OA2	21	12	6	22
OA4	14	7	3	12

The variations in transit time could be caused by delays in the aerial port at Dover or any of the ports enroute to the pallet's APOD. In order to look at one of the delays a pallet may face, the delay time at Dover was calculated by subtracting the Julian date the pallet was built (PAL_DT) from the Julian date when the pallet departed DOV (DEP_DT_TM). Table 16 shows the delays at Dover experienced by all pallets in the data set whose initial departure from Dover was tracked. The average delay time at the Dover aerial port was found to be 3 days with a standard deviation of 2 days. The three pallets that had a maximum transit time of 36 days were delayed at DOV for 35 days before they departed for their destination.

Table 16. Delays at DOV Aerial Port in days

Delay at DOV	Count	Percentage	Delay at DOV	Count	Percentage
0	31	0.98%	10	18	0.57%
1	561	17.66%	11	12	0.38%
2	928	29.21%	12	3	0.09%
3	617	19.42%	13	9	0.28%
4	347	10.92%	14	2	0.06%
5	262	8.25%	17	1	0.03%
6	165	5.19%	35	3	0.09%
7	95	2.99%	Total	3177	100.00%
8	74	2.33%	Average	3	
9	49	1.54%	Std Dev	2	

A pallet can travel direct from the APOE to its APOD or it may go through an enroute APOD before it reaches the final APOD. In the network discussed in this research, a pallet will have a maximum of two enroute stops before making it to the final APOD. These two stops generate more opportunities for that pallet to be delayed and thus have an increased transit time. If pallets sit in the pallet yard of the APOE for an average of three days before they depart, part of this time may be able to be used to accumulate more cargo so the pallet can built to the NGCC goals. Once the pallet leaves the APOE, the goal is to move that pallet as quickly as possible to the desired APOD. Delays at enroute stops can be decreased if the pallets are built so they can be transferred from one aircraft to the other without having to be rebuilt by the aerial port.

Proposed Utilization Goals

The current NGCC utilization goals were set with good intentions to provide better utilization of the aircraft and thus better use of AMC aircraft. However, the current goals may be found confusing by aerial porters who are building the pallets because they

have multiple utilization goals for the same pallet type. For example, an L pallet for a B747-200 has a cube utilization goal of 485 ft^3 and weight utilization goal of 4800 lbs while the L pallet for a B747-400 has a cube utilization goal of 475 ft^3 and weight utilization goal of 5800 lbs.

The current NGCC goals also only have two pallet types that provide the aisle way required for the C-130 wheel well position and one pallet type that meets the aisle and height restrictions for the C-130 ramp position. Assuming the June 2010 data set is representative of the mix of pallets that travels from Dover to Afghanistan annually, hundreds of pallets would need to have an aisle way built into them by an enroute aerial port before they could fit into the wheel well or ramp positions on a C-130. If the aerial ports are unable to build the aisle ways on the pallets more C-130 missions would be required to meet the delivery time of the cargo.

The researcher proposes that more of the pallets be built with aisle ways to prevent in-theater aerial ports from having to reconfigure the pallets. In order to encourage this, the researcher is proposing the new utilization goals found in Table 17.

Table 17. Proposed utilization goals

Pallet Type	Length (in)	Width (in)	Height (in)	Weight (lbs)	Cube (ft^3)	Ramp?	Wheel Well?
B	84	84	76	3410	310	Y	
E	84	98	60	3146	286		Y
F	84	98	96	5027	457		Y
H	84	84	76	3410	310	Y	
J	84	98	94	4928	448		Y
L	84	104	96	5335	485		
N	84	98	70	3663	333		Y
P	84	98	70	3663	333		Y
Q	84	104	76	4224	384		
R	84	84	76	3410	310	Y	

The proposed utilization goals have five pallet types that can fit in a wheel well pallet position on a C-130 and three pallet types that can fit in the ramp pallet position. In order to determine if the weight goal for the pallets was consistent with the pallets in the June 2010 data set, the researcher analyzed the density of the pallets by dividing the pallet gross weight (PLT_GROSS_WT) by pallet volume (PLT_VOL). The average density of the pallets in the June 2010 data set was found to be 14.87 lb/ft^3. The NGCC utilization goals are based on a density of approximately 10.10 lb/ft^3. Figure 10 shows a histogram of the density of the pallets.

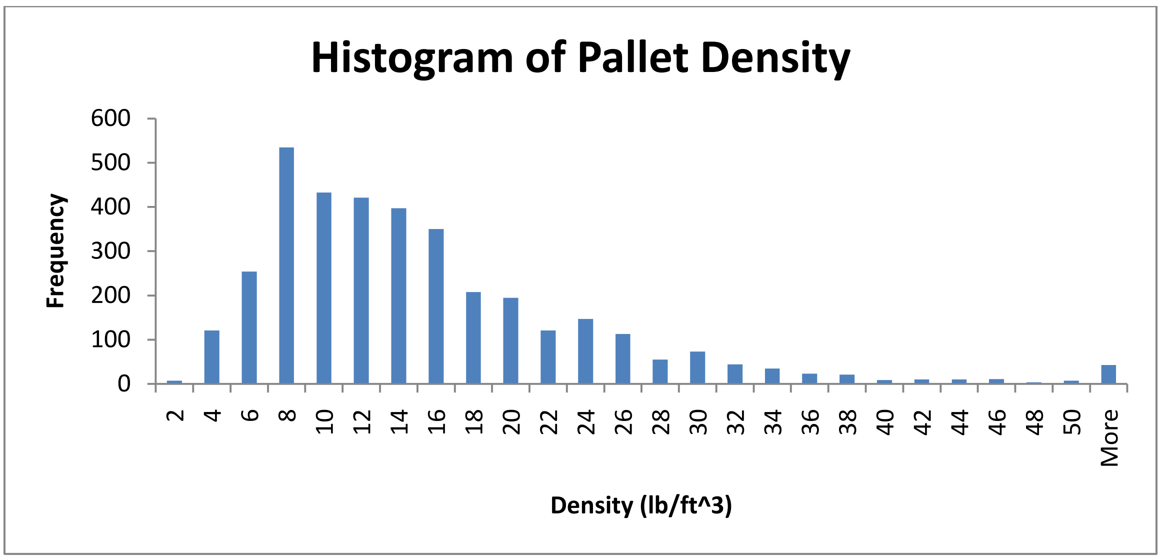


Figure 10. Histogram of Pallet Density

The median of the densities was found to be 12.24 lb/ft^3 which indicate the majority of pallets have a density less than the average. Although the average and median density's are higher, the proposed pallet utilization weight goals were found using a density of 11.00 lb/ft^3. Table 18 shows how the proposed weight goals compare to current utilization and the NGCC goals. The proposed weight goals provide an increase of 24.43% in the weight of cargo moved if all pallets are built to 100% of the utilization goal and 11.99% if they are built to 90% of the goal weight.

Table 18. Comparison of Proposed Weight Goals

PLT_TY_CD	Count	Average Weight (lbs)	NGCC Goal (lbs)	90% NGCC (lbs)	New Goal (lbs)	90% New (lbs)
B	317	3,628	3,880	3,492	3,410	3,069
E	1,015	2,584	3,062	2,756	3,146	2,831
F	1	6,870	4,527	4,074	4,928	4,435
H	0	0	3,133	2,820	3,410	3,069
J	0	0	4,618	4,156	5,027	4,524
L	2,089	4,142	4,800	4,320	5,335	4,802
N	113	2,899	4,729	4,256	3,663	3,297
P	5	2,592	3,810	3,429	3,663	3,297
Q	17	2,716	4,143	3,729	4,224	3,802
R	16	1,625	3,000	2,700	3,410	3,069
Total moved	3,573	12,844,820	15,041,475	13,537,524	15,982,505	14,384,935
Difference		0	2,196,655	692,704	3,137,685	1,540,115
Percent		0.00%	17.10%	5.39%	24.43%	11.99%

Table 19. Comparison of Proposed Cube Goals

PLT_TY_CD	Count	Average Cube (ft^3)	NGCC Goal (ft^3)	80% NGCC (ft^3)	New Cube (ft^3)	80% New (ft^3)
B	317	270	384	307	310	248
E	1,015	168	303	242	286	229
F	1	231	448	358	448	358
H	0	0	310	248	310	248
J	0	0	457	366	457	366
L	2,089	371	475	380	485	388
N	113	198	468	374	333	266
P	5	84	377	302	333	266
Q	17	161	410	328	384	307
R	16	103	420	336	310	248
Total Moved	3,573	1,058,719	1,490,455	1,191,851	1,452,955	1,162,516
Difference		0	431,736	133,132	394,236	103,797
Percent		0.00%	40.78%	12.57%	37.24%	9.80%

The cube goals were kept the same for F, H, J, and L pallets and they were decreased for all other pallet types. The cube goal for all pallet types was significantly higher than the average cube for the data provided. Table 19 shows how the proposed cube goals compare to current cube and the NGCC goals. The new cube goals are lower than the NGCC utilization goals; however, they provide a 37.24% increase in volume if pallets are built to 100% utilization and 9.80% increase in volume if the pallets are built to 80% of the utilization goal.

The proposed pallet dimensions generate more pallets that can fit into the C-130 wheel well and ramp pallet positions. In order to analyze how the proposed pallet sizes would impact the number of C-130 missions required, the data for all pallets travelling to non-hub airfields in Afghanistan was run through the linear program in Appendix D. The results are shown in Table 20.

Table 20. Number of C-130 Missions Required For New Pallet Goals

	AZ3	JAA	MZR	OA2	OA4	TE2	Total
June 2010 Data	80	32	38	18	19	4	191
NGCC Goals	96	42	45	22	33	5	243
New Goals	75	30	35	20	23	3	186

The new utilization goals were able to move the same number of pallets in 186 missions, five less than the current number of missions required. A reduction of five C-130 missions equates a savings of approximately $35,000 to move the same amount of cargo, as well as making that aircraft available for other missions.

Summary

This chapter began by describing the data that was used for this research. The data was then analyzed to determine how the pallets built in June 2010 compared to the NGCC utilization goals. A linear program was used to determine the impact on intra-theater aerial ports by determining the number of C-130 sorties required to move the pallets to non-hub airfields. The transit times were calculated for the pallets which had reached their final APOD in order to determine how the increased port hold time at the APOE might affect delivery time. Finally, the researcher proposed new utilization goals that were focused on meeting the aisle way requirements for the C-130 and showed how these goals compared to the current NGCC utilization goals. While this chapter focused on the specific findings and analysis, Chapter V focuses on the implications of these results.

V. Conclusions and Recommendations

Introduction

The objective of this research was to determine if the pallet utilization goals proposed by the Next Generation Cargo Capability (NGCC) initiative would have an impact on intra-theater airlift. This was addressed by answering three questions: How do the NGCC pallet utilization goals differ from current pallet building procedures? Does increasing pallet weight/volume at the APOE effect intra-theater aerial port operations? Does an increasing pallet weight/volume requirement increase the time it takes for supplies to be delivered to troops in theater? This chapter presents the major conclusions drawn from the results and analysis of this research effort and provides recommendations for changes to the current NGCC pallet utilization goals and future research on this topic.

Conclusions

USTRANSCOM has whole heartedly accepted the role of Distribution Process Owner (DPO) and has implemented several initiatives to ensure that the DoD supply chain is both efficient and effective. Several of these initiatives have focused on ensuring that the movement of goods by air is not only operating effectively, but efficiently as well. In 2004 USTRANSCOM and AMC implemented the pure pallet program to help speed materiel and supplies to the war fighters on the ground in Iraq and Afghanistan. The success of the pure pallet program has set the bar high for the latest initiative, the Next Generation Cargo Capability (NGCC).

NGCC is a USTRANSCOM and AMC initiative that is looking at implementing standardized pallet utilization goals in an effort to increase pallet utilization and thus increase overall aircraft utilization. The goal of the program is to increase the velocity of the flow of goods through the distribution pipeline as well as improve aircraft utilization. The objective of the program is to hold pallets longer at the APOE which will allow for more cargo to accumulate and result in bigger pallets. The larger pallets should result in overall more cargo being moved by each aircraft which would mean that the valuable air transportation assets are being used more efficiently. It is thought that the increased hold time at the APOE will also reduce the bottlenecking of cargo at intra-theater aerial ports which should increase the velocity of goods moving through the supply chain.

The NGCC pallet utilization goals are specified by aircraft and module type. This means that a pallet leaving the APOE on a Boeing 747 would be built to the goals for that aircraft. However, as cargo flows through the DTS, it may be moved via several different airframes before it reaches the APOD. This could result in the pallet having to be rebuilt at enroute aerial ports which would increase the time it takes to reach its final destination.

This research focused on exploring the impact that the NGCC pallet utilization goals would have on the intra-theater airlift portion of the supply chain. The primary airlift asset used to move cargo once it has reached the theater is the C-130. The C-130 is the smallest airlifter in the AMC fleet which poses unique challenges for load planners. Three of the C-130's six pallet positions require an aisle way be built into the pallet. This means that the pallet must be built with the appropriate aisle way or that the personnel at the intra-theater aerial port will have to rebuild the pallet, a job they are not manned to accomplish.

The research found that only 59.87% of pallets that left Dover for Afghanistan in June of 2010 met the proposed NGCC utilization goals. If the pallets had been built to the NGCC utilization goals, a 17.10% increase in weight or 40.78% increase in volume of cargo moving through the DTS would be experienced. However, the researcher found that there was a 27.23% increase in the number of C-130 sorties required to move the cargo destined for the non-hub airfields. The NGCC goals only specified three pallet types (H, J, and R) that would fit in the wheel well and ramp pallet positions on the C-130. The June data had 154 pallets that met the weight and aisle way requirements for the ramp or wheel well position on the C-130. This allowed the cargo to be moved in 191 sorties. When the NGCC utilization goals were applied to the same mix of pallets there were not any pallets that would fit in the ramp or wheel well positions which meant that only three pallets could be moved per leg. Therefore, 243 sorties were required to move the same pallet mix if they had been built to NGCC utilization goals. Another option would be for the aerial ports to rebuild the pallets to meet the aisle way requirements. They would be required to rebuild 149 pallets to move all the pallets in the same number of sorties they could currently be moved in.

An increase in the number of C-130 missions required to move the cargo or increased port hold times to build an aisle way onto the pallets does not meet the NGCC goal of increased velocity. The increased pallet utilization the NGCC goals provide would greatly increase the efficiency of the DTS; however, it would be at the cost of effectiveness. In order to determine if increased pallet utilization could be beneficial without decreasing effectiveness, the researcher developed new pallet utilization goals with several pallet types that would meet the C-130 aisle way restrictions. These new

goals have five pallet types that would fit in the wheel well position and three that would fit in the ramp position. The proposed goals are based on the current density of cargo moved resulting in increased weight goals while decreasing the cube goal of several pallet types to accommodate aisle ways. The proposed goals represent an increase in the weight moved by 24.43% and an increase in the cube moved by 9.80%. The introduction of aisle ways onto more of the pallets also resulted in a decrease in the number of C-130 sorties required to move the cargo to the non-hub airports from 191 to 186.

The proposed goals are not necessarily the best solution for this problem; however, they show that the NGCC initiative is able to provide both increased utilization of pallets and aircraft as well as increased velocity through the distribution pipeline. This research does not prove that the NGCC initiative will be able to meet the goals of improved efficiency and improved effectiveness. It does however provide a basic analysis that such an initiative could be beneficial to the DTS.

Recommendations

The researcher recommends that the pallet utilization goals be revisited to look at the limitations posed by the aircraft used in the DTS. Specifically, they should focus on the number of pallet types that are compatible with the C-130 ramp and wheel well aisle way requirements. This would prevent the intra-theater aerial ports from having to rebuild the pallet to accommodate an aisle way. As well as possibly reducing the number of C-130 sorties required to meet the requirements.

The author also recommends educating all the personnel on why this initiative is being put in place and what the benefits of the program are. The pure pallet program was

initiated in 2004 but a study in 2006 found that only 25% of the aerial porters and logisticians had heard of the program and knew what the objectives were (Dye, 2006: 102). Educating the personnel on it should result in a greater overall understanding of the program and benefits it brings to the warfighter. This recommendation could be accomplished in a number of ways including commander's calls, computer based training, or even a training video.

Recommendations for Future Research

In addition to the recommendations above, there are ample opportunities for further research into this topic. The researcher was unable to garner a good understanding of how the increased NGCC hold times would affect the overall customer wait time in the process. The researcher recommends further research into current port hold time at the APOE and intra-theater aerial ports to determine how implementation of the NGCC initiative would affect the velocity of the flow through the DTS.

Another area for further research would be to perform an analysis on the results of the proof of principle that began in October 2010. This would provide actual data of what the pallets built under the NGCC utilization goals would look like and if they could be reconfigured to meet C-130 aisle way requirements. The actual number of missions to move the cargo could also be compared to determine if the increased pallet sizes have impacted the number of sorties required. This data could also provide valuable knowledge of the impact of the NGCC goals on intra-theater aerial ports.

Finally, a survey to gain the perspective of aerial porters and logisticians currently working in the theater and at the APOEs on how increased pallet utilization would impact

their daily operations would be valuable. The data can be analyzed after the fact, but getting the perspective of people working the initiative on a daily basis would truly provide first-hand knowledge of how the NGCC is impacting the aerial ports and overall distribution pipeline.

Summary

This chapter presented the major conclusions drawn from the result and analysis of this research as well as several recommendations for improvements in the program and further research. The results indicate that the NGCC objective of improving both the efficiency and effectiveness of the DTS by increasing pallet utilization is a viable concept. However, the author recommends that the current NGCC utilization goals be revisited to focus on the limitations of all aircraft operating in the DTS. The researcher also presented recommendations for educating the aerial port personnel and logisticians as well as areas for future research.

Appendix A. Pallet Type Codes

PLT_TY_CD	Description
A	Non-unitized, Rolling Stock
B	Pallet up to 76 inches
C	Containerized, skidded cargo
D	Pallet for 727/707/DC-9/L-100/DC-8 stretched model
E	Pallet up to 60 inches
F	Pallet for DC-10 (2L-12R), MD-11(2-14)
G	Pallet with a propeller
H	C-130 Ramp pallet
I	ISU pallet
J	Pallet for C-130 (6" aisle way)
K	KC-135
L	Pallet for B-747 (upstairs), C-5, C-17, C-130, C-141, L-100
M	C-5 or C-17 only
N	KC-10 (PP 2-10 L+R)
P	KC-10 (position 1)
Q	KC-10, MD-11, DC-10 > rear positions
R	Pallet for C-5 (14" aisle way - PP 1,2,35,36)
S	Logistics pallet train for C-17
T	Throughput pallet
U	A-300 pallet train
V	Stack of empty pallets
W	Pallet with LOX cart
X	Pallets for DC-8 combi
Y	ADS pallet train
Z	Breakbulk pallet

Appendix B. NGCC Utilization Goals by Pallet Type

Utilization Goals							
B	B Module Pallet (Positions 1-5)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
B747-200	84	104	76	3880	384	3840	5
B747-400	84	104	76	4582	384	3840	5
D	D Module Pallet (Positions 1-16)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
C-9	84	104	56	2860	283	2830	1
DC-8 Stretch	84	104	79	3840	380	3800	16
E	E Module Pallet (Lower Lobe)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
B747-200	84	104	60	3062	303	3030	9
B747-400	84	104	60	3625	303	3030	9
MD-11	84	104	60	3062	303	3030	6
F	F Module Pallet (MD-11 Positions 2-14 L&R)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
MD-11	84	104	96	4527	448	4480	26
DC-10	84	104	96	4527	448	4480	22
H	H Module Pallet						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
C-130	84	84	76	3133	310	3100	1
C-130J	84	84	76	3133	310	3100	1
L-100	84	84	76	3133	310	3100	1
J	J Module Pallet						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
C-130	84	98	96	4618	457	4570	2
C-130J	84	98	96	4618	457	4570	2
L-100	84	98	96	4618	457	4570	2

K	K Module Pallet (Positions 1-6)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
KC-135	84	104	65	3254	322	3220	6
L	L Module Pallet						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
C-5	84	104	94	3500	475	4750	32
C-130	84	104	94	4800	475	4750	3
C-130J	84	104	94	4800	475	4750	5
L-100	84	104	94	4800	475	4750	5
C-17	84	104	94	4800	475	4750	18
B747-200	84	104	96	4800	485	4750	28
B747-400	84	104	94	5800	475	4750	28
N	N Module Pallet (Positions 2-10 L&R)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
KC-10	84	104	96	4729	468	4680	18
P	P Module Pallet (MD-11 Positions 1 L&R)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
KC-10	84	104	74	3597	356	3560	2
MD-11	84	104	75	3810	377	3770	1
Q	Q Module Pallet (MD-11 Positions 15-17 L&R)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
KC-10	84	104	88	3951	391	3910	4
MD-11	84	104	96	4143	410	4100	6
DC-10	84	104	96	4143	410	4100	6
R	R Module Pallet (14" Aisleway Positions)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
C-5 (1,2)	84	90	96	3000	420	4200	2
C-5(35,36)	84	90	70	2500	306	3060	2
X	X Module Pallet (Positions 1-10)						
Aircraft	L	W	H	Scale Weight	Cube	Cube Weight	Pallets
DC-8	84	104	79	3840	380	3800	10

Appendix C. Cargo Type Codes

PALLET _TYPE	Description
BC	Belly Cargo
LS	Loose Cargo
PC	Palletized Cargo
RS	Rolling Stock
SD	Skid
T*	Pallet Train (The 2nd digit denotes the number of pallets)

Appendix D: Linear Program Algorithm

Inputs:

X_R = number of pallets that can fit in the C-130 ramp position
X_W= number of pallets that can fit in the C-130 wheel well position
X_L = number of remaining pallets that can fit in positions 1, 2, or 5 on the C-130

Variables:

X_1 = number of missions with 1 pallet
X_2 = number of missions with 2 pallets
X_3 = number of missions with 3 pallets
X_4 = number of missions with 4 pallets
X_5 = number of missions with 5 pallets
X_6 = number of missions with 6 pallets

Objective:

MIN Missions Required = $X_1 + X_2 + X_3 + X_4 + X_5 + X_6$

Subject to:

$X_1, X_2, X_3, X_4, X_5, X_6$ = integer	(number of missions must be integer)
$X_1, X_2, X_3, X_4, X_5, X_6 \geq 0$	(number of missions must be greater than 0)
$X_{1R}, X_{2R}, X_{3R}, X_{4R}, X_{5R}, X_{6R} \geq 0$	(number of ramp pallets remaining must be greater than 0)
$X_{1W}, X_{2W}, X_{3W}, X_{4W}, X_{5W}, X_{6W} \geq 0$	(number of ramp pallets remaining must be greater than 0)
$X_{1L}, X_{2L}, X_{3L}, X_{4L}, X_{5L}, X_{6L} \geq 0$	(number of ramp pallets remaining must be greater than 0)
$X_{5R} = 0$	(number of ramp pallets remaining for missions with 5 pallets is 0)
$X_{4W} = 0$	(number of wheel well pallets remaining for missions with 4 pallets is 0)
X_{1L}=0	(number of L pallets remaining for missions with 1 pallet is 0)

	A	B	C	D	E	F	G
1			Initial Pallet		Redistributed		
2			Distribution		Pallets		
3		Ramp Pallets		OKAY	0		
4		WW Pallets			0		
5		Ppos 1,2,5			0		
6							
7		Pallets per	Number of	Remaining Pallets			
8		Mission	Missions	Ramp	Wheel Well	Other	
9		6 pallets		0	0	0	
10		5 pallets		0	0	0	
11		4 pallet		0	0	0	
12		3 pallet		0	0	0	
13		2 pallet		0	0	0	
14		1 pallet		0	0	0	
15							
16		Total Msns	0				

Figure 11. Linear program in Excel

Equations:
D2 = IF(C5<(3*C3),"REDISTRIBUTE",IF(((C3+C4)/3)<C3,"REDISTRIBUTE","OKAY"))
E3 = IF(D3="REDISTRIBUTE",IF(C5<(3*C3),ROUNDDOWN((SUM(C3:C5)-E5)/3,0),ROUNDDOWN((SUM(C3:C4)/3),0)),C3)
E4 = SUM(C3:C5)-E3-E5
E5 = IF(D3="REDISTRIBUTE",IF(C5<(3*C3),ROUNDUP(SUM(C3:C5)/2,0),C5),C5)
D9 = E3-1*C9
E9 = E4-2*C9
E10 = E5-C9*3
D10 = D9
E10 = E9-C10*2
F10 = F9-C10*3
D11 = D10
E11 = E10-C10*2
F11= F10-C10*3
D12 = D11
E12 = E11-C10*1
F12 = F11-C10*3
D13 = D12
E13 = E12
F13 = F12-C10*2
D14 = D13
E14 = E13
F14 = F13-C10*1

Bibliography

"A15-1 Aircraft Reimbursement Rates". 22 December 2010. Retrieved 14 February 2011 from the Air Force Portal website: https://www.my.af.mil

"Aircraft Capabilities". (n.d.). Microsoft PowerPoint Presentation. Attachment to e-mail from SSgt David Cazalet on 15 February 2011.

"Aircraft Scheduling Rapid Improvement Event". 2010. Microsoft PowerPoint Presentation. Attachment to e-mail from Mr. Gerritt McCrory, 11 August 2010.

"Air Freight Computer Based Training". (n.d.). Retrieved 8 April 2011, from Air Mobility Command Advanced Distributed Learning Systems website: https://amc.csd.disa.mil/kc/main/kc_frame.asp?blnWhatsNew=True

Air Mobility Command (AMC). "Air Terminal Operations Center". AMCI 24-101 Vol. 9. Scott AFB, IL: Air Mobility Command, 24 November 2009. http://www.e-publishing.af.mil

---. "Civil Reserve Air Fleet Load Planning Guide Boeing 747". AMCPAM 24-2 Vol. 2. Scott AFB, IL: Air Mobility Command, 1 December 2001. http://www.e-publishing.af.mil

---. "Civil Reserve Air Fleet Load Planning Guide McDonnell Douglas MD 11". AMCPAM 24-2, Vol. 8. Scott AFB, IL: Air Mobility Command, 1 December 2001. http://www.e-publishing.af.mil

---. "Transportation: Cargo and Mail Policy". AMCI 24-101 Vol. 11. Scott AFB, IL: Air Mobility Command, 7 April 2006. http://www.e-publishing.af.mil

Anderson, David and Timothy W. Gillespie, "Integrating Air and Ground: Joint Theater Distribution System", *Air Force Journal of Logistics*, Vol. XXXII (4): 24-34 (2008).

Baker, Steven F. et al., "Optimizing Military Airlift", *Operations Research*, Vol. 50 (4): 582-602 (July/August 2002).

Brigantic, R.T. and D. Merrill, "The Algebra of Airlift", *Mathematical and Computer Modeling*, Vol. 39: 649-656 (2004).

Chan, Felix T.S. et al., "Development of a decision support system for air-cargo pallets loading problem: A case study", *Expert Systems with Applications*, Vol. 31: 472-485 (2006).

Cochard, Douglas D. and Kirk A. Yost, "Improving Utilization of Air Force Cargo Aircraft", *Interfaces*, Vol. 15: 53-68 (1985).

Department of Defense. “Cargo Movement”. Defense Transportation Regulation (DTR) Part II. Washington, D.C.: Department of Defense, 25 September 2009. http://www.transcom.mil.

---. “DoD Supply Chain Materiel Management Regulation”. DoD 4140.1-R. Washington, D.C.: Department of Defense, 23May 2003. http://www.dtic.mil/

Diamond, M. (2005). *New AMC delivery process speeds shipments to troops*. Defense AT&L.

“Dover Aircraft Utilization Point of Principle Rules of Engagement”. Attachment to e-mail from Mr. Gerritt McCrory, 11 Aug 10.

Dye, M.T. (2006). *Perceptions of the Pure Pallet Program*. Masters Thesis, AFIT/GLM/ENS/06-04. School of Logistics Management, Air Force Institute of Technology (AU), Wright-Patterson AFB, OH.

Finney, Randy and Mike Hansen. “Next Generation Cargo Capability (NGCC)”. 2010. Microsoft PowerPoint Presentation. Attachment to e-mail from Mr. Gerritt McCrory, 11 Aug 10.

Finney, Randy. “Next Generation Cargo Capacity (NGCC) Talking Paper”. 2010. Microsoft Word Document. Attachment to e-mail from Mr. Gerritt McCrory, 11 Aug 10.

Gray, M.S. (2010). *The Effects of Cargo Height Distribution On B-747 And C-17 Airlift*. Masters Graduate Research Project, AFIT/IMO/ENS/10-06. School of Logistics Management, Air Force Institute of Technology (AU), Wright-Patterson AFB, OH.

Jackson, William L. (2007). *The Viability of the Air Mobility Command Pure Pallet Program for US Army Reparable Retrograde Shipments*. Masters Thesis, AFIT/GLM/ENS/07-05. School of Logistics Management, Air Force Institute of Technology (AU), Wright-Patterson AFB, OH.

Koepke, Corbin G. et al., “An integer programming approach to support the US Air Force’s air mobility network”, *Computers and Operations Research*, Vol. 35:1771-1788 (2008).

“Load Planning Computer Based Training”. (n.d.). Retrieved April 8, 2011, from Air Mobility Command Advanced Distributed Learning Systems website: https://amc.csd.disa.mil/kc/main/kc_frame.asp?blnWhatsNew=True

Lovell, James. “Bullet Background Paper on Next Generation Cargo Capability”. 4 Dec 09.

"Max Pallet Goals MASTER 29 July 10". 2010. Microsoft Excel Spreadsheet. Attachment to e-mail from Mr. Gerritt McCrory, 11 Aug 10.

Mongold, Michael B. and Alan W. Johnson, "Pure Pallets: Effectiveness and Efficiency Impacts on the Defense Transportation System", *Journal of Transportation Management*, Vol. 17 (1):18-36 (Spring 2006).

Ng, Kevin Y.K., "A Multicriteria Optimization Approach to Aircraft Loading", *Operations Research*, Vol. 40 (6):1200-1205 (2006).

Peterson, Kirk. "Break Bulk OPS." Email to Sandra Wilson. 21 March 2011.

Rappoport, Harold K et al., "Estimating Loads of Aircraft in Planning for the Military Airlift Command", Interfaces, Vol. 21: 63-78 (1991).

TCJ5/4-S. "Governance Structure". 25 Aug 10. DPO: Distribution Process Owner. Web. 18 Sep 10. http://www.transcom.mil/dpo/.

U.S. Joint Chiefs of Staff. Distribution Operations. Joint Publication 4-09. Washington, D.C.: U.S. Joint Chiefs of Staff, 5 February 2010. http://www.dtic.mil/doctrine/new_pubs/jointpub_logistics.htm

U.S. Transportation Command (USTRANSCOM). "2010 Annual Command Report". Scott AFB, IL: USTRANSCOM, 15 Apr 11. Web. Accessed 18 Apr 11. http://www.transcom.mil.

---. "2010 Annual Command Report". Scott AFB, IL: USTRANSCOM, 15 Apr 11. Web. Accessed 18 Apr 11. http://www.transcom.mil.

---. "Proposed Uniform Rates and Rules for International Service". Scott AFB, IL: USTRANSCOM, 7 July 2010. Provided via email from Dr. James Moore on 31 March 2011.

---. "Understanding the Defense Transportation System". USTRANSCOM Handbook 24-4. 6th ed. Scott AFB, IL: USTRANSCOM, 30 January 2009. http://www.transcom.mil

Yan, Shangyao et al., "Cargo Container Loading Plan Model and Solution Method for International Air Express Carriers", *Transportation Planning and Technology*, Vol. 29 (6): 445-470 (2006).

Blue Dart – Impact of Increased Pallet Utilization on Intra-Theater Airlift

U.S. Transportation Command (USTRANSCOM), the Distribution Process Owner (DPO) for the Department of Defense (DoD) supply chain, is responsible for moving all cargo from the United States to the combat zone. They have implemented a new initiative known as the Next Generation Cargo Capability (NGCC) whose goal is to obtain better pallet utilization for cargo traveling along the DoD supply chain by increasing either the size or weight of the pallet. As pallets travel along the supply chain they may be transported via multiple airframes and each airframe has a different cargo capability. The intra-theater airframes that are utilized for the final leg of the supply chain have the lowest cargo capability.

NGCC implements weight and volume standards for pallet utilizations that are based on the aircraft's cargo weight and size limitations. The NGCC rules of engagement call for pallets to be built to 90% of the maximum weight or 80% of the maximum volume by pallet position.

The goal of this research is to determine if the implementation of standards, mandating all pallets departing the APOE be built to a specific weight or volume requirement, affects the intra-theater portion of the DoD supply chain. In order to assess this, pallets transported between Dover AFB, DE and the Afghanistan Area of Operations (AOR) in June 2010 were analyzed to determine how they compared to the NGCC utilization goals. The movement of pallets within the theater was analyzed to determine the impact the NGCC goals might have on the intra-theater portion of the airlift system.

In order to determine how the pallets built in June 2010 compared to the NGCC utilization goals the researcher broke the data down in two ways, by aircraft and by pallet type. Utilization rates were calculated for weight, height, and cube. The overall percentage of pallets leaving DOV that met NGCC utilization goals for the aircraft they were on was found to be 59.87%. The overall percentage of pallets built at Dover that met the NGCC utilization goals for their pallet type was found to be 70.22%.

The total cargo weight and cube were calculated for the June 2010 data to determine how these total would change if the pallets were built to the NGCC goals. If all pallets were built to 100% of the NGCC weight and cube goals 17.10% more cargo could be moved and 40.78% more cargo volume could be carried.

The researcher also performed an analysis of cost savings that could be realized by this initiative. Contract rates for commercial carriers are provided as a cost per ton-mile. Therefore, increasing the tons provided increases the amount paid for the commercial aircraft. However, the rate for DoD aircraft is based on cost per flying hour and thus increased pallet utilization will provide for more cost-efficient use of organic aircraft.

In order to determine how the intra-theater aerial ports would be affected by the NGCC utilization goals, the data set was reduced to pallets that were destined for one of the non-hub APOD's. The pallets were broken down by the pallet APOD and the number of C-130 missions required was calculated using a linear program. All pallets were considered to be built to 100% of the utilization goal for their pallet type code The original data did not include any H or J type pallets and therefore there are only three C-130 pallet positions that could be used on each mission. The analysis of the actual data

showed all pallets could be moved in 191 missions. If all pallets were built to the NGCC standard for that pallet type, 243 missions would be required. In order to move the pallets in the same amount of missions required currently, the intra-theater aerial ports would be required to build an aisle way into 149 pallets each month for which they aren't manned. To avoid a need to increase missions or personnel, the researcher proposed new goals which accommodated the C-130 aisle way restrictions. The C-130 friendly goals showed that all the pallets could be moved in 186 missions.

The proposed goals are not necessarily the best solution for this problem; however, they show that the NGCC initiative is able to provide both increased utilization of pallets and aircraft as well as increased velocity through the distribution pipeline. This research does not prove that the NGCC initiative will be able to meet the goals improved efficiency and improved effectiveness. It does however provide a basic analysis that such an initiative could be beneficial to the DTS.

Impact of Increased Pallet Utilization on Intra-Theater Airlift

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Advanced Study of Air Mobility

Introduction

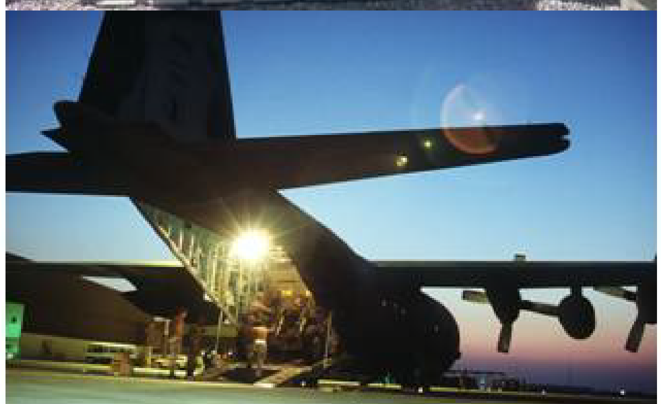
USTRANSCOM has implemented a new initiative known as the Next Generation Cargo Capability (NGCC) whose goal is to obtain better pallet utilization for cargo traveling in the Defense Transportation System (DTS) by increasing either the size or weight of the pallet. As pallets travel through the supply chain they may be transported via multiple airframes and each airframe has a different cargo capability. This research attempts to determine the impact of building larger pallets on the intra-theater portion of the airlift system.

Motivation

Increased pallet utilization can generate cost savings through a reduction in the number of missions required to move cargo. The intra-theater airlifters have the most restrictive cargo capability and therefore might be impacted by the use of larger pallets.

Research Goals

1. Determine how NGCC utilization goals compare to current pallet utilization.
2. Determine if larger pallets will impact intra-theater aerial port operations.
3. Determine if larger pallets will impact delivery time to troops in theater.



Approach

Utilization was compared by aircraft the pallet departed the APOE on and by pallet type. A linear program was used to look at the number of C-130 missions required and number of pallets that must be rebuilt to understand the impact on intra-theater aerial ports. Transit time and an analysis of how pallets were meeting their RDD was used to determine how NGCC might affect delivery time to theater.

Impacts/Contributions

The research showed that increased pallet utilization goals could lead to more efficient use of aircraft. However, the utilization goals must be tailored to meet C-130 aisle way requirements in order to avoid an increase in the number of C-130 missions required to deliver the cargo or an increase in the workload for intra-theater aerial ports who would have to rebuild the pallets.

	C-130 Missions Required to Move Cargo to APOD						
Utilization Goals	AZ3	JAA	MZR	OA2	OA4	TE2	Total
Actual June 2010	80	32	38	18	19	4	191
NGCC	96	42	45	22	33	5	243
C-130 Friendly	75	30	35	20	23	3	186

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
17-06-2011	Graduate Research Paper	May 2010 - June 2011

4. TITLE AND SUBTITLE THE IMPACT OF INCREASED PALLET UTILIZATION ON INTRA-THEATER AIRLIFT	**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) Wilson, Sandra J. , Maj, USAF	**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Institute of Technology Graduate School of Engineering and Management (AFIT/EN) 2950 P Street, Building 640 WPAFB OH 45433-7765	**8. PERFORMING ORGANIZATION REPORT NUMBER** AFIT/IMO/ENS/11-16
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Mr. Don Anderson/ Air Mobility Command A9/AA9 402 Scott Drive / Unit 3M12 Scott AFB, IL 62225 DSN 779-4329; donald.anderson-02@scott.af.mil	**10. SPONSOR/MONITOR'S ACRONYM(S)** **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

12. DISTRIBUTION / AVAILABILITY STATEMENT

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

U.S. Transportation Command (USTRANSCOM) has implemented a new initiative known as the Next Generation Cargo Capability (NGCC) whose goal is to obtain better pallet utilization for cargo traveling in the Defense Transportation System (DTS) by increasing either the size or weight of the pallet. As pallets travel through the supply chain they may be transported via multiple airframes and each airframe has a different cargo capability. This research attempts to determine the impact of building larger pallets on the intra-theater portion of the airlift system. Pallets transported between Dover AFB, DE and the Afghanistan Area of Operations (AOR) were analyzed to determine how they compared to the NGCC utilization goals as well as the impact of these goals on intra-theater aerial port operations. The results show that increased pallet utilization will increase the amount of cargo moved to theater however, if the pallets are not tailored for the intra-theater aircraft, the number of missions required to move pallets within the AOR will increase. A recommendation was made to tailor more pallets to the requirements of the intra-theater aircraft to enjoy the benefits of increased pallet utilization without increasing the number of missions required. .

15. SUBJECT TERMS

Intra-theater Distribution, Pallet Utilization, Cargo Handling, Next Generation Cargo Capability, Aerial Port Operations

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					James T. Moore, Ph.D., AFIT/ENS
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	UU	90	**19b. TELEPHONE NUMBER** *(include area code)*
U	U	U			(937) 255-3636 x4528